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CONTENTS

A New Species of Frog, Genus *Nyctimystes*, from Papua. By *Wilfred T. Neill* 83

A New *Rana* from the Pliocene of California. By *Richard G. Zweifel* 85

Variation and Sexual Dimorphism in Hatchlings of the Rainbow Snake, *Abastor erythrogrammus*. By *Neil D. Richmond* 87

Size and Growth of the Two-lined Salamander, *Eurycea bislineata rivicola*. By *William E. Duellman and John T. Wood* 92

Dimorphism in Larval Mouthparts in Spadefoot Toads of the *Scaphiopus hammondi* Group. By *Grace L. Orton* 97

Variation in a Large Litter of Gartersnakes, *Thamnophis sirtalis sirtalis*. By *Bernard Martof*. 100

Identification of the Amphibia and Reptilia Recorded in Jamaica by Hans Sloane (1688–89). By *Robert H. Ahrenfeldt* 105

Habits of the Lizard, *Liolaemus multiformis multiformis* at High Altitudes in Southern Peru. By *Oliver P. Pearson* 111

Systematic Position of the Lake Trout, *Salvelinus namaycush*. By *Wm. Markham Morton and Robert Rush Miller* 116

Observations on the Pygmy Whitefish, *Prosopium coulteri*, from Bull Lake, Montana. By *George F. Weisel and John B. Dillon* 124

Oklahoma Lampreys: Their Characterization and Distribution. By *Gordon E. Hall and George A. Moore* 127

A New Species of Fish of the Genus *Blennius* from Florida. By *William N. Tavolga* 135

Geographic Variation in the Pacific Herring. By *J. L. McHugh* 139

Ichthyological Notes

Food studies of young sciaenid fishes, *Micropogon* and *Leiostomus*, from North Carolina. By *Eugene W. Roelofs* 151

Presence of an axillary venom gland in the oriental catfish *Plotosus lineatus*. By *Bruce W. Halstead and Robert L. Smith* 153

First record of the white perch (*Morone americana*) in Lake Erie. By *Alfred Larsen* 154

The identity of the parrotfish *Scarus ahula*, the female of *Scarus perspicillatus*. By *Vernon E. Brock and Yoshio Yamaguchi* 154

Records of four cyprinid fishes of the genera *Notropis* and *Semotilus* from central Texas. By *Kenneth C. Jurgens* 155

Herpetological Notes

Observations on Autumn movements of the salamander *Ambystoma tigrinum tigrinum* in southeastern Michigan. By *William E. Duellman* 156

Another noteworthy range extension of the toad *Bufo punctatus* in Texas. By *Richard J. Baldauf and Rexford D. Lord, Jr.* 157

The barking frog, *Hyla gratiosa*, in the Cumberland Plateau of Georgia. By *Bernard Martof* 157

Loggerhead turtles, *Caretta caretta caretta*, from North Carolina. By *William E. Fahy* 157

The narrow-mouthed toads *Microhyla olivacea* and *M. carolinensis* in northeastern Oklahoma. By *Hague L. Lindsay, Jr.* 158

Fossil rattlesnakes of the genus *Crotalus* from northern Massachusetts. By *Richard van Frank and Max K. Hecht* 158

Reviews and Comments—Voices of the night (phonographic records); by Peter Paul Kellog and Arthur A. Allen, *by Coleman J. Goin:* 159.—Historical aspects of organic evolution; by Philip G. Fothergill, *by J. Speed Rogers:* 160.—Die Fischdressuren und ihre sinnesphysiologischen Grundlagen; by Konrad Herter, *by Arthur D. Hasler:* 161.—Bibliography of the noises made by marine organisms; by W. N. Kellogg, *by Norman J. Wilimovsky:* 161.—Fishes found in the freshwaters of Texas; by Frank T. Knapp, *by Reeve M. Bailey:* 162.—The fresh-water fishes of British Columbia; by G. Clifford Carl and W. A. Clemens, *by Robert Rush Miller:* 163.—Culture and diseases of game fishes; by H. S. Davis, *by Gerald P. Cooper:* 163.—The Black River studies; by John L. Funk, et al.: 163.

Editorial Notes and News—Alfred Cleveland Weed, 1881–1953: 163.—Bibliography of A. C. Weed: 164.—Retirement of E. W. Gudger: 164.—Bashford Dean Memorial Library: 165.—University of Florida: 165.—Chicago Natural History Museum: 166.—Revolving Research Fund: 166.—Collectors in México: 166.—News Notes: 167.

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A New Species of Frog, Genus *Nyctimystes*, from Papua

WILFRED T. NEILL

IN July and August, 1943, I was stationed near Taburi, Papua. Here I collected an apparently new *Nyctimystes*. At hand is a preserved example of this species, and a color painting of its appearance in life. Also available are detailed drawings of a second specimen, showing profile, anal region, open mouth, tarsus, forelimb, hindlimb, hand, foot, and general appearance; and drawings of a third example showing profile, open mouth, dorsal view of head, forearm, and foot. Measurements of these last two frogs were made, along with color descriptions from life. Five other specimens were examined and briefly described in my notes.

The species is named in honor of Arthur Loveridge, of the Museum of Comparative Zoology, Harvard University.

***Nyctimystes loveridgei*, sp. nov.**

Fig. 1

HOLOTYPE.—Museum of Comparative Zoology No. 27823, adult male; small stream near Taburi, a native village about 2 miles southeast of Rouna Falls, Papua; July 30, 1943; W. T. Neill, collector.

DIAGNOSIS.—Outer finger half-webbed; snout longer than eye diameter; head flattened; tongue small, oval, free posteriorly; a small lappet on the heel; no palpebral reticulum; male with a rudimentary vocal sac; digital disks small, subcircular; ground color mottled green, yellow, brown, and black; a dark-bordered light band across the body, coinciding with a similar band on each tibia when the frog is at rest; a dark-bordered light band between the eyes, and a similar band on each forearm.

DESCRIPTION OF TYPE.—Tongue small, oval, with a free, notched prolongation posteriorly. Vomerine teeth in two short, oblique series between the choanae. Head flattened, slightly wider than long. Snout longer than eye diameter. A bluntly rounded canthus rostralis. Lore oblique, at an angle of about 55° from the vertical. Nostril much closer to tip of snout than to eye. Distance between anterior corners of lids slightly less than snout length. Interorbital space as broad as upper eyelid. Maximum diameter of tympanum about four-fifths of eye diameter. Pupil a broad, vertical ellipse.

Upper arm very short, concealed under body; forelimb permanently flexed. Hand flat, paper-thin. Inner finger free, thumb-like, with black nuptial pad; other fingers half-webbed. Disks of fingers subcircular, diameter of largest less than half that of tympanum. Hindlimb very long; tibio-tarsal articulation of adpressed leg extending beyond snout. Penultimate joint of fourth toe free from web; other toes fully webbed. Disks of toes subcircular; diameter of fourth toe disk about two-thirds that of tympanum. Subarticular tubercles moderately well developed; inner metatarsal tubercle small, rounded.

Body flattened, tapering abruptly from wide head to very narrow waist.

Skin smooth above, granular on flanks, chin, belly, and lower surfaces of thigh. A small, curved supratympanic fold. An inconspicuous flange of skin on outer edge of forearm, extending from elbow to disk of outer finger; a similar but more prominent flange on outer edge of tarsus, from heel to disk of outer toe. A small, triangular lappet on heel. Throat with small folds of loose skin, suggesting rudimentary external vocal sac. Three rows of anal warts, those of uppermost row papilliform.

COLOR IN LIFE.—Ground color, above, mottled with light green (close to 18 I 4 in Maerz and Paul, Dictionary of Color, 2nd ed.), yellow (close to 10 K 1), dull brown (close to 15 C 10), and dark grayish-black. A light yellowish-green band (close to 19 G 1) across the body, this band bordered with dark grayish-black. A similar dark-bordered band on each tibia and forearm, and another between eyes. Lower surfaces of head, body, hand, foot, and limbs pale yellowish-white (close to 11 D 1). Most of thigh colored like venter; only a narrow

strip along top of thigh colored like dorsum. Fourth finger and disk of third finger mottled above like dorsum; remainder of hand, inner surface of forearm, and most of upper arm pale like venter. Fifth toe and disk of fourth toe

Fig. 1. *Nyctimystes loveridgei*, sp. nov. Type specimen showing pattern in life. Actual snout–vent length, 47.5 mm.

mottled above; remainder of foot pale. A narrow, irregular grayish-white line on edge of upper jaw. Dermal flanges of fore- and hindlimb grayish-white.

The type has darkened greatly in preservative. The mottled areas have become dark purplish-brown, and the pale under surfaces are now flesh-colored.

MEASUREMENTS (IN MM.)—(Of freshly killed type and two other examples.) Snout–vent length 47.5, 45.8, 39.5; groin to tip of longest toe 76.0, 72.3, 79.9; maximum head width 16.0, 15.8, 15.9; head length 15.5, 15.2, 15.4; eye diameter 5.0, 4.6, 4.7; snout length 7.0, 6.5, 6.9; maximum tympanum diameter 4.4, 3.5, —.

VARIATION.—All the specimens examined were calling males, closely similar to the type in size and general appearance. In one example the dermal flange along the forearm was more pronounced than in the type; in another the tarsal flange was less pronounced. The patches of vomerine teeth varied in shape from oval to round or irregular. In one frog the heel reached far beyond the tip of the snout when the hindlimb was adpressed. Some of the frogs were more heavily dark-mottled, others paler and less mottled, than the type.

REMARKS.—The new form does not appear to be closely allied to any previously recognized species. *Nyctimystes papua* (Boulenger) has scant webbing of the outer finger, a shorter snout, a head not conspicuously depressed, and pronounced ventral mottling. *N. gularis* Parker is a short-snouted form with scant webbing of the outer finger, a much smaller tympanum, a vocal sac opening into the mouth, and a metallic venation of the lower eyelid. *N. granti* (Boulenger) is a much larger species, with a head not conspicuously flattened; the snout is shorter, a palpebral reticulum is present, there is no papilla on the heel, the tympanum is smaller and indistinct, and the tongue is subcircular. *N. montana* Parker has a smaller tympanum, truncate and larger digital disks, a palpebral reticulum, and a vocal sac opening into the mouth. *N. semipalmata* Parker has a palpebral reticulum and a subcircular tongue which is larger and scarcely free behind; the tympanum is smaller, the digital disks larger and truncate, the legs shorter. *N. milneana* Loveridge has shorter legs, no lappet on the heel, a larger and subcircular tongue which is scarcely free behind, and (presumably) a palpebral reticulum. The color pattern of the new species apparently is unique.

Certain New Guinean frogs, currently referred to *Hyla*, seem very close to *Nyctimystes*. Several species display a lappet on the heel and dermal flanges on the forearm and tibia. *Hyla montana* Peters and Doria is especially *Nyctimystes*-like.

The genus *Nyctimystes* has been distinguished from *Hyla* chiefly by the presence of a vertical pupil in the former, but this character is not always evident in preserved specimens. Thus, in the preserved type of *N. loveridgei* the pupil appears to be circular, although it was vertically elliptical when the living specimen was exposed to sunlight. The pupil was also fully expanded in the unique type of *N. milneana*, which was

classified for 20 years as *H. montana*. Other species of *Nyctimystes* may well be masquerading as *Hyla* in various collections.

HABITAT AND HABITS.—Taburi lies at an altitude of perhaps 2,000 feet (2,177 feet at Hombron Bluff, 7 miles to the northwest; 2,615 feet at Mt. Warirata, 4½ miles to the west), in rugged country. Mean annual rainfall is probably around 100 inches (108 inches at Sogeri, 4½ miles to the northeast). The region is one of dense forest, with tall hardwoods, moderately thick underbrush, numerous epiphytes, and a damp humus layer. In the area are many small, rapid streams, with steep banks and rocky beds. The streams are tributary to the Laloki River.

A photograph of Rouna Falls appeared in *The National Geographic Magazine*, September, 1929, page 263. It affords an excellent idea of the country about the type locality, 2 miles to the southeast.

Nyctimystes loveridgei was collected only along one small stream. The calling males were sitting on wet, slippery rocks, and when disturbed they dived into the water and were swirled away by the current. Very agile and alert, they were difficult to catch. The frogs appeared only during hard rains at night; I could not find them at any other time. No female was collected. The call of the male was a series of five or six raucous notes, like laughter. Very active, steel-blue tadpoles, seen in the stream, were perhaps of this species.

When the frog is at rest, the limbs are folded and partly tucked beneath the body. The only exposed surfaces are those of the head and dorsum, the outer portion of the forearm, the fourth finger, the disk of the third finger, a narrow strip along the top of the femur, the upper portion of the tibia, the outer edge of the tarsus, the fifth toe, and the disk of the fourth toe. These surfaces, and only these, are mottled; a curious economy of pigmentation. The depressed head and body, the relatively small digital disks, the moss-like coloration, and the disruptive pattern of coincident light bands all suggest that this frog dwells about rocks or the mossy boles of trees.

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A New *Rana* from the Pliocene of California

RICHARD G. ZWEIFEL

FOSSIL Anura have rarely been reported from the Pacific Coast states. Only a single extinct species (*Bufo nestor* Camp, 1917) has been described, and mention has been made of three others: *Rana* and *Bufo* sp. (Savage, 1951: 226) and the Recent *Bufo boreas* (Camp, *op. cit.*).

Through the courtesy of Dr. Charles L. Camp, the author has been permitted to examine and describe a fossil *Rana* from the middle Pliocene of central California.

***Rana pliocenica*, sp. nov.**

HOLOTYPE.—No. 1037/34564, Museum of Paleontology, University of California. Posterior part of skeleton including the fifth vertebra, excluding only some phalanges and the pubis. Fragments of anterior elements also present (Fig. 1).

HORIZON AND TYPE LOCALITY.—Middle Pliocene (Hemphillian), Pinole Tuff. Shore of San Pablo Bay, ½ mile NE of Rodeo, Sec. 2, T2N, R4W, Contra Costa County, California. Collected in 1938 by Works Progress Administration party supervised by Arthur K. White.

DIAGNOSIS.—A species of *Rana* characterized by a relatively deep medial groove on the ventral surface of the sacral vertebra (Fig. 2) and a relatively deep ilial blade.

MEASUREMENTS (IN MM.).—Length of ilial blade, 22.0; greatest depth of ilial blade, 4.1; length of tibia, 39.2; length of vertebrae six and seven, 6.3; length of astragalus, 17.4.

DISCUSSION.—The sacral vertebra possesses the typical ranid characteristics of cylindrical diapophyses and paired condyles articulating with the urostyle. The eighth (first presacral) vertebra has been displaced from the vertebral

column so that its amphicoelous nature (a ranid characteristic) is readily apparent. The other skeletal elements closely resemble those of living members of the genus *Rana*. The extinct *Anchylorana*, described by Taylor (1942) from the Pliocene of Kansas and characterized by the fusion of the sacral vertebra and urostyle, is the only other ranid genus living or fossil known from the Western Hemisphere.

Comparison has been made with pertinent skeletal parts of eight forms of living ranas (the number in parentheses indicates the number of skeletons utilized): *Rana aurora draytoni* (7); *R. a. cascadae* (7); *R. boylei boylei* (23); *R. b. sierrae* (6); *R. catesbeiana* (1); *R. pipiens* (1); *R. pretiosa* (4); and *R. tarahumarae* (1). The subspecies of *R. aurora* and *R. boylei* were treated separately because of the probability that four rather than two distinct species are involved.

Among the characters investigated were the depth of the blade of the ilium and the length of the tibia. As mentioned in the above diagnosis, *Rana pliocenica* is characterized by a relatively deep ilium. The ilial depth (measured at the deepest point) may be expressed by means of two ratios: greatest depth of blade to length of blade, and greatest depth of blade to length of vertebrae six plus seven. The vertebrae chosen are articulated in the normal way in the fossil. There appears to be more intraspecific variation in length of blade than in depth. The coefficient of variability for the two ratios cited above, using the largest available series of skeletons of a single form (23 *Rana b. boylei*) is V = 11 percent for the first ratio and V = 7 percent for the second.

TABLE I

PROPORTIONAL MEASUREMENTS (AVERAGE AND RANGE) OF SKELETAL ELEMENTS IN CERTAIN SPECIES OF *Rana*

Id = ilium depth; Il = ilium length; Vl = length of vertebrae 6 + 7; Tl = tibia length.

Species	No.	Id/Il	Id/Vl	Vl/Tl
pliocenica	1	.186	.650	.161
aurora draytoni	7	.180±.017 .163–.198	.735±.031 .646–.885	.154±.016 .141–.172
catesbeiana	1	.202	.729	.195
pipiens	1	.152	.632	.154
boylei boylei	23	.145±.003 .117–.180	.586±.014 .489–.693	.139±.007 .118–.157
tarahumarae	1	.144	.562	.159
boylei sierrae	6	.130 .103–.155	.554 .414–.665	.146 .137–.156
aurora cascadae	7	.129 .107–.147	.510 .463–.554	.159 .146–.168
pretiosa	4	.127 .105–.153	.496 .432–.574	.167 .138–.181

Rana boylei, *R. tarahumarae*, *R. aurora cascadae* and *R. pretiosa* have slender ilia very unlike the fossil species (Table I). *R. pipiens* resembles the fossil in one expression of ilial depth, while *R. aurora draytoni* is more like it in the other. *R. catesbeiana* has a more massive ilium than *R. pliocenica* by either measure.

The ratio of length of vertebrae six plus

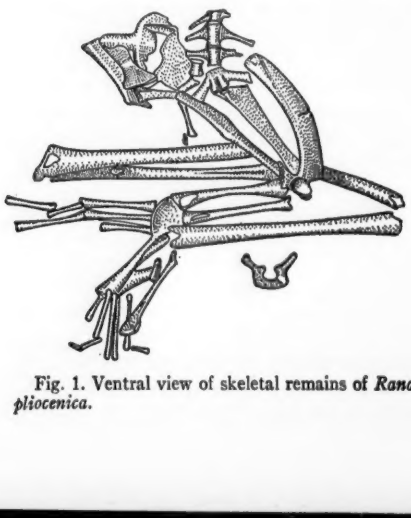

Fig. 1. Ventral view of skeletal remains of *Rana pliocenica*.

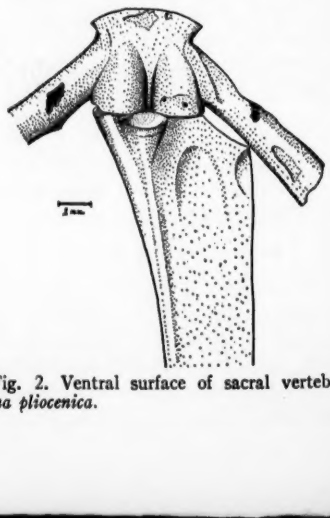

Fig. 2. Ventral surface of sacral vertebra of *Rana pliocenica*.

seven to tibial length shows that *R. catesbeiana* has the shortest tibia of any of the frogs considered, differing considerably in this respect from the fossil. Length of tibia further removes *R. boylei* from the picture.

Rana pliocenica differs from all recent species examined in the depth and anterior extent of the mid-ventral groove of the sacral vertebra (Fig. 2). In the living species the bases of the condyles are little elevated, consequently the lower surface of the sacral vertebra is relatively flat. In the fossil, the presence of paired slight elevations with a depression between restricts the flat area to the antero-ventral half of the centrum.

Recently La Rivers (1953) has described *Rana johnsoni* from the lower Pliocene of western Nevada. The type specimens of *R. pliocenica* and *R. johnsoni* have been directly compared. *Rana johnsoni* differs conspicuously from *R. pliocenica* in possessing a long, slender ilial blade.

With its relatively short legs and slender ilium, *R. johnsoni* does not appear to be closely allied to *R. aurora*, but may be closer to the frogs of the *Rana boylei* complex or possibly to *R. pretiosa*. Both these latter forms have relatively slender ilia.

Of the living western species, *R. pliocenica* most nearly resembles *R. aurora draytoni*, both in ilial proportions and in general body size. The resemblance to *R. pipiens* is also close, but it seems unlikely that this most widely distributed (both ecologically and geographically) of North American frogs would have become extinct in the Pacific Coast region had it once reached it. *Rana pliocenica* may represent the Pliocene predecessor of *R. aurora*. Paleobotanical studies by D. I. Axelrod have shown that types of plant communities with which *R. aurora* is associated today were well developed in central California in Middle Pliocene time. Frogs ecologically equivalent to *R. aurora*, possibly *Rana pliocenica*, were probably similarly associated with such plants in the Pliocene.

Literature Cited

Camp, C. L. 1917. An extinct toad from Rancho La Brea. *Univ. California Publ. Bull. Dept. Geol., 10: 287–92.*

La Rivers, I. 1953. A lower Pliocene frog from western Nevada. *Jour. Paleo., 27: 77–81.*

Savage, D. E. 1951. Late Cenozoic vertebrates of the San Francisco Bay region. *Univ. California Publ. Bull. Dept. Geol. Sci., 28: 215–314.*

Taylor, E. H. 1942. Extinct toads and frogs from the Upper Pliocene deposits of Meade County, Kansas. *Univ. Kansas Sci. Bull., 28: 199–235.*

Museum of Vertebrate Zoology, University of California, Berkeley, California.

Variation and Sexual Dimorphism in Hatchlings of the Rainbow Snake, *Abastor erythrogrammus*

Neil D. Richmond

THE rainbow snake, *Abastor erythrogrammus* Latreille, is relatively difficult to collect or observe throughout most of its range, and little has been published on its nests or young. During the summer of 1952, four nests of this snake were found and two lots of eggs were hatched in the laboratory. Using the hatchlings obtained from these eggs, with additional specimens collected during the winter, a study was made of their individual variation and sexual dimorphism. The specimens are in the collections of the Carnegie Museum (CM).

Material and Methods

The specimens examined are from an extremely localized population in New Kent County, Virginia, near Lanexa. All are from the same sandy field habitat previously described for this snake by Richmond (1945). The largest series of 58 hatchlings (CM 31268) are from two lots of eggs that were collected August 22, 1952, and hatched in the laboratory. These were preserved as follows: 20 when 0–5 days old, 24 when 42–52 days old, and 14 at various ages as they died in captivity. Three more

hatchlings (CM 31288–90) and three mature specimens were obtained in December 1952. On February 22, 24 hatchlings (CM 31303) and 7 mature specimens were found. All of the nests, and specimens collected in the field were found by plowing a total of approximately two acres. The 24 hatchlings collected in February were estimated to be about 150 days old, assuming that they had hatched during September. The data for the 58 specimens from two nests were compared to those for the 27 hatchlings from different nests, and no significant differences other than size were found. In the following discussion and tables the data used are those for the entire series of 85 specimens (39 ♂, 46 ♀), except where otherwise noted.

The statistical methods are from Simpson and Roe (1939). For the statistical data summarized in Table I, the following notations are used: N = number in sample, M = arithmetic mean, R = overall range, σ = standard deviation, V = coefficient of variation. For the M, σ, and V, the standard error is also given. The amount of difference between the sexes is given as the coefficient of divergence (Klauber 1940a).

Growth of Hatchlings

Although the hatchlings in the laboratory did not feed, and it is assumed that the hibernating hatchlings in the field did not feed, the three groups show an increase in length associated with age. There is, however, no significant difference in weight associated with either sex or age in the 68 hatchlings that were weighed. The combined data for the series are: N = 68, R = 3.60–7.86 grams, M = 5.92±0.13 grams, σ = 1.12±0.10, and V = 18.92±1.62. In the first five months the average increase in total length for both sexes was 24 mm. (Fig. 1).

Shedding

Approximately two weeks after hatching most of the snakes in the laboratory shed for the first time. However, in one group of snakes that hatched between September 6 and 17, there were two that did not shed until October 7, a minimum of 20 days later. Four snakes that hatched September 17 shed 11 days later and again on November 14, when they were 58 days old. The group that was approximately 52 days old when preserved included snakes that had just shed as well as those almost ready to shed.

Sexual Dimorphism in Size and Proportions

The females appear to be slightly longer than males. In each age group the longest specimens are females and the shortest are males, excepting one abnormally short specimen in the 150-day-old females. In each group the females average 4–9 mm. longer than males, although the difference between the means in the two older age groups is not statistically significant. In all groups there is considerable overlap in individual measurements (Fig. 1).

In each age group the males have a longer tail than the females, the average difference being 5–6 mm. In the two youngest groups there is no overlap in individual measurements, but the oldest group, which is also the most heterogeneous, shows some overlap in individual measurements (Fig. 2).

In head–body length the females average 9 to 14 mm. longer than males of the same age, although there is considerable overlap in individual measurements (Fig. 3).

There is no difference in the proportionate

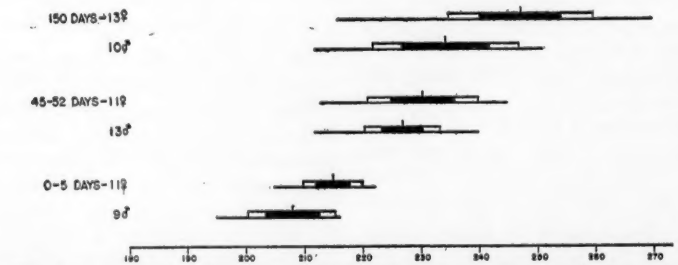

Fig. 1. Increase in total length of *Abastor* hatchlings from 5 days to 150 days old.
The line indicates range; black rectangle twice the standard error on each side of the mean; light rectangle one standard deviation on each side of the mean.

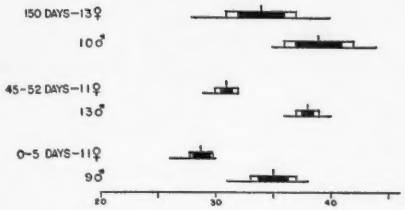

Fig. 2. Growth and sexual dimorphism in tail length of hatchlings.

Line indicates range; black rectangle twice the standard error on each side of the mean; light rectangle one standard deviation on each side of the mean.

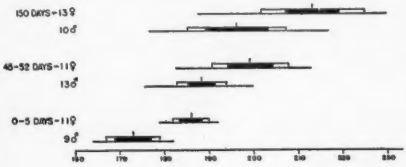

Fig. 3. Increase in head–body length of hatchlings.

Line indicates range; black rectangle twice the standard error on each side of the mean; light rectangle one standard deviation on each side of the mean.

length of the tail in the different age groups but the sexes are distinct. In the males the tail averages 16.7 percent of total length compared to 13.5 percent in the females (Table I).

Sexual Dimorphism in Scutellation

For studying variations in scutellation the entire series of 85 hatchlings (39 ♂, 46 ♀) was used (Table I). In number of ventrals the sexes are completely separated. The males average 159.3, while the females average 172.1. The sexes are also completely distinct in number of subcaudal scales. The females, with their much shorter tail, average 37.6, while the males average 46.5 caudals.

Since females have the most ventrals and the fewest caudals, the greatest numerical difference between the sexes is obtained by subtracting the number of caudals from the number of ventrals. With this figure the sexes are widely separated with a difference of 12 between the highest count for males and the lowest count for females. When these two counts are combined, they tend to reduce the numerical difference between the sexes but sexual dimorphism is still apparent.

Table I

Variation and Sexual Dimorphism in the Scutellation of Hatchlings of *Abastor*

Characters	Sex	N	Min.	Max.	Mean	Standard deviation	Coefficient of variation	Coefficient of divergence, percent
Ventrals	♂	39	155	162	159.3±.24	1.48 ±.17	0.93± .11	7.67
	♀	46	170	175	172.0±.18	1.20 ±.13	0.7 ± .07	
Caudals	♂	39	44	49	46.5±.15	0.95 ±.11	2.04± .23	21.17
	♀	46	35	42	37.6±.19	1.31 ±.14	3.48± .36	
Ventrals anterior to scar	♂	39	131	138	135.6±.31	1.93 ±.22	1.42± .16	5.45
	♀	46	139	147	143.2±.30	2.01 ±.21	1.40± .15	
Ventrals posterior to scar	♂	39	17	23	20.1±.21	1.35 ±.15	6.72± .76	23.30
	♀	46	23	29	25.4±.25	2.98 ±.31	11.73±1.22	
Ventrals minus caudals	♂	39	108	116	112.8±.27	1.69 ±.19	1.50± .17	17.15
	♀	46	128	139	134.5±.29	1.95 ±.20	1.45± .15	
Ventrals plus caudals	♂	39	202	210	205.8±.28	1.78 ±.20	0.87± .10	1.88
	♀	46	207	215	209.7±.24	1.59 ±.17	0.76± .08	
Proportion of tail in percent of total length	♂	37	15.8	17.6	16.7±.075	0.144±.02	0.86± .01	20.46
	♀	46	12.7	15.3	13.6±.068	0.144±.02	1.06± .11	

Edgren (1951) found a differential position of the umbilical scar correlated with sex in *Heterodon platyrhinos*. In this series of *Abastor* the position of the umbilical scar is also an accurate index of sex. In females there are more ventral scales both anterior and posterior to the scar than there are in the males. The number of ventral scales interrupted by the scar is usually four or five, although one specimen had seven scales included in the scar. The anterior end of the scar interrupts ventral number 131–138, mean 135.6 in the males; in females, 139–147, mean 143.2. The males have 17–23 ventrals posterior to the umbilical scar, mean 20.1; the females, 23–29, mean 25.4.

Relationship of Total Number of Ventrals to Position of Scar

The position of the umbilical scar is related to the total number of ventrals. This relationship is approximately linear. The greater the total number of ventrals the higher the number of ventrals anterior to the scar.

In most species of snakes the umbilical scar disappears leaving no mark of its former position. However, in *Abastor*, the position of the umbilical opening is indicated throughout life by a faint, light line in the red ground color of the venter and by a shallow indentation in the rear margin of the scales that were broken by the umbilical opening. This was still apparent in the largest specimen examined, a female 1,336 mm. long.

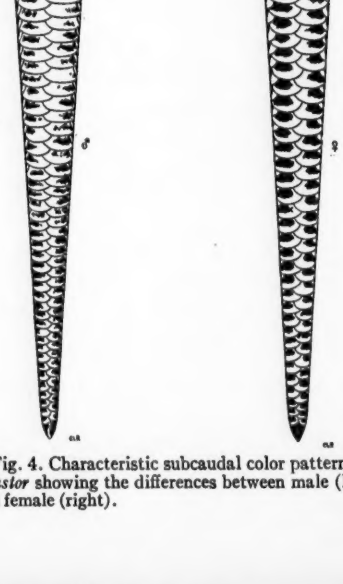

Fig. 4. Characteristic subcaudal color patterns of *Abastor* showing the differences between male (left) and female (right).

Sexual Dimorphism in Color Pattern

Sexual dimorphism in color pattern is rare among snakes (Davis, 1936) and it is even rarer for such differences to be sufficiently marked to distinguish the sexes. The series of *Abastor* hatchlings displays well defined differences in color pattern that are associated with sex.

The most constant pattern difference between the sexes is in the two rows of spots on the lateral margins of the subcaudal scales. In the female these spots are distinct, approximately half as wide as the scale, and are arranged in two unbroken rows throughout the entire caudal series. The males have a much more variable subcaudal pattern; the spots are small, less than half the width of the scale, irregular in shape and size, and not arranged in two rows. Usually several of the subcaudals lack spots and in four males the subcaudals are entirely unspotted. This character is so constant that the sexes can be easily separated on this basis alone (Fig. 4).

The mid-ventral row of spots also shows sexual dimorphism. All but one of the males have a distinct unbroken row of spots starting on ventral number 9 to 30. Twenty-nine of the 46 females resemble the males in this respect, while 17 of them have the mid-ventral row of spots poorly developed. On these females, the spots are reduced and irregular in size and absent from many of the scutes. This character is easily seen and distinguishes approximately 27 percent of the females in this series of hatchlings. The position and width of the dorsal and lateral stripes is constant throughout the series. The row of spots on each margin of the ventral scales is also constant except for minor variations in the size of the spots.

Variation

The most surprising variation in this group of hatchlings is the high frequency of snakes

with an undivided or single anal plate. In all other genera of North American snakes except *Trimorphodon* the condition of the anal plate is almost invariable. In *Trimorphodon* it is usually divided except in the species *vandenburghi* which usually has a single anal plate (Klauber, 1940b). Although the genus *Trimorphodon* is unusual in having both types of anal plate, the species within the genus are relatively constant in this character, less than six percent of the specimens of a species departing from the normal condition for that species. In most genera the frequency of variation in the anal plate is much lower, usually less than one percent. A typical example is *Seminatrix*. In a study of 403 specimens Dowling (1950) found only two with an undivided anal plate, approximately 0.5 percent.

In this series of 85 *Abastor* hatchlings, 9 males and 13 females have a single anal plate (25.9 percent). To test whether or not this variation might be peculiar to the young from one nest or associated with sex, the series was divided according to sex and origin. The 27 specimens collected in the field had the highest percentage of individuals with a single anal plate, ranging from 27.3 percent in the males to 37.5 percent in the females. Of nine mature specimens from the same locality, five have a divided, and four have a single anal plate.

Apparently this unusual variation is a characteristic of this local population of *Abastor*. Although the females in both groups have a higher percentage of undivided anal plates, a test for association of this character with sex did not show any significant relationship, (X^2 = .294; P > .5). When the series was grouped according to the type of anal plate, no significant differences could be found in scutellation or measurements.

For purposes of tabulation the anal plate was listed as either single or divided although as the character occurred in the series there were several in which the plate was partially divided. In these the base of the scale was divided but the division ended before reaching the edge of the scale. Unless the scale was completely divided into two separate scales it was considered undivided.

It appears that in *Abastor* the type of anal plate has no survival value, nor is it associated with any character that has; so, if the two types of anal plates once become established in a population, they could remain. The present situation is probably a reflection of the degree of isolation of this particular population from the parent population farther south.

Anomalies

At the base of the tail the dorsal scale rows undergo an abrupt reduction in number from 19 to 8 rows within 20 mm. This reduction is accomplished by the fusion of two or more scale rows rather than by the dropping of rows. Characteristically the mid-dorsal row ends at a large plate that represents the fusion of the mid-dorsal with one or both of the rows on each side of it. There may be 1 to 8 of these plates, each 2 to 3 scale rows wide. These may be followed by one or more scales that are two rows in width (Fig. 5). As the lateral rows fuse they are replaced by a row of large scales that are two rows in width. The number of large scales inserted on the mid-dorsal line is not constant. Thirty-six of the specimens have one to eight of these scales, three rows wide, while the remainder have one or more groups of scales two rows in width.

Six of the specimens (4 ♂, 2 ♀) have the last ventral divided.

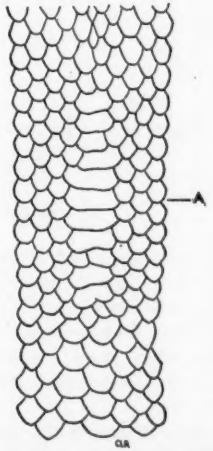

Fig. 5. Dorsal view of *Abastor* (CM 17567, ♀) showing fusion of scale rows in region from the seventh ventral anterior to the anal plate to the ninth subcaudal.

A = position of anal plate

SUMMARY

A series of 85 hatchling *Abastor erythrogrammus* were collected in one locality in New Kent County, Virginia. Using these a study was made of variation and sexual dimorphism.

Sexual dimorphism is very much pronounced in hatchling *Abastor*. Distinct differences between the sexes are apparent in body length, tail length, relative tail length, number of caudals, number of ventrals, and position of umbilical scar. With these numerical differences there is little or no overlap of measurements or counts. In total length and in the combined number of ventrals and caudals there are still differences between the sexes too great to permit combining the sexes for any statistical study of *Abastor* populations.

The hatchlings grow approximately 24 mm. in total length during the first five months after hatching, a period when they are normally in hibernation and presumably are not feeding.

This population of *Abastor* also shows differences in color pattern that are associated with sex.

This population of *Abastor* is characterized by a high frequency of individuals with a single anal plate, averaging 25 percent of the specimens examined. This is a greater variation in this character than has been recorded for any other North American snake. No sexual dimorphism was apparent in the distribution of this character.

ACKNOWLEDGEMENTS

The author wishes to express appreciation to Dr. M. Graham Netting and Dr. Dana Snyder for their many helpful criticisms and suggestions, and to Charles L. Ripper for the drawing of Figures 4 and 5, and to Clifford Morrow for the preparation of Figures 1, 2, and 3.

LITERATURE CITED

DAVIS, D. DWIGHT. 1936. Courtship and mating behavior in snakes. *Field Mus. Zool. Ser., 20 (22): 257–90.*

DOWLING, HERNDON. 1950. Studies of the black swamp snake, *Seminatrix pygaea* (Cope), with descriptions of two new subspecies. *Misc. Pub. Mus. Zool., Univ. Michigan, 76: 1–38.*

EDGREN, RICHARD A. 1951. The umbilical scar, a sexually dimorphic character in *Heterodon platyrhinos. Nat. Hist. Misc., 83: 1–2.*

KLAUBER, LAURENCE M. 1940a. Two new subspecies of *Phyllorhynchus*, the leaf-nosed snake, with notes on the genus. *Trans. San Diego Soc. Nat. Hist., 9 (20): 195–214.*

——— 1940b. The Lyre snakes (genus *Trimorphodon*) of the United States. *Ibid., 9 (19): 163–94.*

RICHMOND, NEIL D. 1945. The habits of the Rainbow snake in Virginia. COPEIA *(1): 28–30.*

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Size and Growth of the Two-lined Salamander, *Eurycea bislineata rivicola*

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SEVERAL years ago we set out to determine the size attained by the two-lined salamander, *Eurycea bislineata rivicola* Mittleman, in southwestern Ohio. We have accumulated series of specimens which enable us to arrive at certain conclusions concerning the size and growth of this form.

The specimens that form the basis for this report were collected in southwestern Ohio and adjacent areas in Indiana and Kentucky. The great majority of the specimens are from Greene and Montgomery counties in Ohio. Nearly all of the larvae were collected at Glen Helen near Yellow Springs, Greene County, Ohio. Series of both larvae and adults have been collected in nearly every month of the year. For aid in the field, we are indebted to Richard S. Brown, Ann S. Duellman, Maurice E. Fitzmaurice, Richard R. Knotts, Mr. and Mrs. Dwight E. Ladd, Alfred E. Verwyst, and Harold J. Walter. Mr. James E. Mosimann assisted with the statistical treatment of the data. Dr. Norman E. Hartweg and Dr. Charles F. Walker have offered much valuable criticism.

During the course of the present study, 781 specimens, including 248 males, 262 females, and 271 larvae, were examined and measured. The snout–vent measurement is the straight-line distance from the anterior tip of the snout to the posterior edge of the vent. The tail length measurement is the straight-line distance from the posterior edge of the vent to the tip of the tail; specimens with injured or regenerated tails were not used. The sex of each individual was determined by dissection.

Eggs of this species have been reported on by various workers. Weichert (1945: 78) stated that in the Cincinnati area the breeding season is limited to the end of March and the first two weeks of April. Dr. Charles F. Walker informed us that in central-southern Ohio he has found fresh eggs of this species from the middle of April through late May. It seems likely that in southwestern Ohio at least some of the eggs hatch in late June, since a series of 19 individuals collected on July 4, 1952, range in total length from 14.0 to 18.5 mm.; these represent the smallest specimens we have examined. This agrees with the findings of Wilder (1924: 4), who found individuals in June and July measuring 14 mm. in total length. Bishop (1943: 408) stated that newly hatched larvae may be as small as 12 mm.

The length of the larval period has not been established definitely. Wilder (1924: 4–5) stated that after one year the larvae measure 33 mm. in total length, and that metamorphosing individuals range in size from 43 to 76 mm., with an average of 52.5 mm. for each sex. She also stated that the larval period lasts from 2 to 3 years, with metamorphosis taking place sometimes as early as May, but usually during the summer months. Bishop (1943: 408) presented similar information; he said that the larvae may reach a length of 68 mm., and that metamorphosis takes place 2 to 3 years after hatching.

We divided our larval specimens into size classes according to date of collection. In July and August three definite size groups, indicating three year classes, are apparent. The mean snout–vent lengths for these three groups in July are 9.18, 20.04, and 25.25 mm. The average snout–vent length of the smallest group of larvae in September and October is slightly more than 15 mm. These data indicate that in southwestern Ohio the larvae hatch in late June with a snout–vent length of slightly less than 9 mm.; that they grow rapidly through the summer, reaching a snout–vent length of more than 15 mm. by September and October; that growth is slower in the winter; and that by the following June when the larvae are one year old they have a snout–vent length of 20 mm. The data further indicate that the larvae grow at a slower rate throughout their second year, and at the age of 2 years have attained a snout–vent length in excess of 25 mm. Several specimens collected in June, July, and August are in late metamorphosis and average about 25 mm. in snout–vent length. Therefore, it seems apparent that the majority of the larvae metamorphose during their third summer. However, large larvae collected in October and November

TABLE I

SNOUT-VENT LENGTHS (IN MM.) OF 271 LARVAL *Eurycea bislineata rivicola* DIVIDED INTO "YEAR CLASSES"

Month	N	Mean	Range	± 2 σx
1st year:				
July	19	9.18	8.0–11.0	0.31
Aug.	24	10.23	9.0–12.0	0.34
Sept.	4	15.90	14.7–17.0	1.25
Oct.	41	15.39	12.5–17.0	0.35
Nov.	2	15.50	14.5–16.5	....
Dec.	6	17.08	16.0–18.0	0.75
Jan.	23	16.02	13.5–18.5	0.55
Feb.	6	16.75	15.0–18.0	1.06
Mar.	1	16.50	.....	....
2nd year:				
June	6	20.00	18.5–21.5	0.97
July	12	20.04	16.5–23.0	1.31
Aug.	14	22.34	20.0–24.0	0.70
Oct.	14	19.21	17.5–22.5	0.75
Nov.	3	21.70	19.5–24.0	....
Dec.	7	20.36	19.0–24.0	1.32
Jan.	10	21.90	19.0–26.0	1.55
Feb.	30	22.70	19.0–27.5	1.30
Mar.	8	24.30	21.0–27.5	1.86
Apr.	4	22.75	22.0–25.0	....
3rd year:				
June	7	26.64	23.0–32.0	2.63
July	14	25.25	24.0–28.0	0.82
Aug.	10	26.85	25.0–30.0	0.92
Oct.	2	30.00	29.0–31.0	....
Nov.	4	26.10	25.5–27.0	....

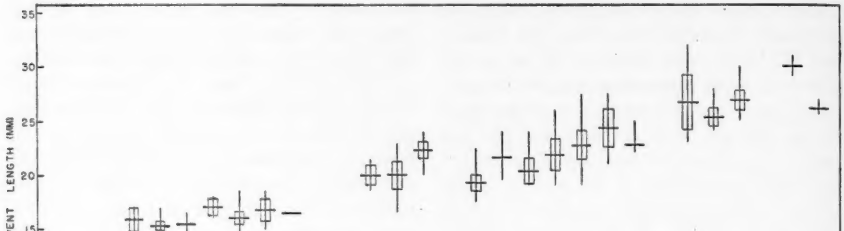

Fig. 1. Snout-vent lengths of 271 larvae of *Eurycea bislineata rivicola* divided into "year classes" and plotted against month of collection. The horizontal line represents the mean of the sample; the vertical line, the range; and the box, plus and minus twice the standard error of the mean.

indicate that a few individuals may metamorphose later in the year, or that some may not metamorphose until they are 3 years old. (Table I; Fig. 1.)

Nineteen individuals of transformation size were examined: ten males and nine females with an average snout-vent length of 26.0 and 25.7 mm., respectively. The average total length of the males is 52.0 mm.; that of the females, 50.9 mm. These specimens were collected in the summer months, as follows: June, 3 ♂, 2 ♀; July, 2 ♂, 5 ♀; August, 5 ♂, 2 ♀. These data do not indicate that one sex transforms earlier than the other, or that there is any difference in size at transformation. However, that transformation may take place at a slightly smaller size than that indicated is shown by a female adult with a total length of 40.0 mm. The smallest transformed male has a snout-vent length of 24.0 mm. and a total length of 47.0

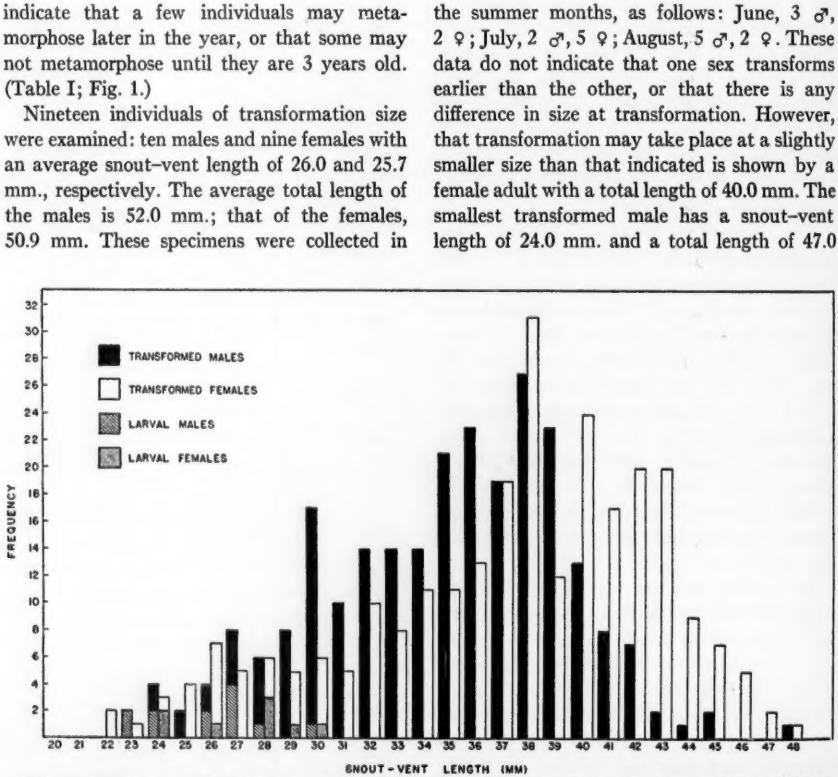

Fig. 2. Snout-vent lengths of transformed (238 males, 256 females) and larval (20) individuals of *Eurycea bislineata rivicola*.

mm. The specimen with a total length of 40 mm. appears to be an exception, as other small transformed females measure from 45 to 50 mm. in total length and have a snout–vent length of 22 to 25 mm. The size at transformation varies considerably, the smallest metamorphosed individuals having a snout–vent length of 22.0 mm. and a total length of 40.0, while the largest individuals have a snout–vent length of 30.0 mm. and a total length of 63.0. The small transformed individuals may have metamorphosed during their second summer, since their size compares favorably with larvae of that age. Our data do not show that there are any individuals that metamorphose at the end of their third year or during their fourth summer as found by Wilder (1924: 5).

It is not possible to detect year classes in adults. The smallest transformed male has a snout–vent length of 24.0 mm.; the largest, 48.0. The females range from 22.0 to 48.0 mm. The average snout–vent length of 238 males is 35.3 mm.; that of 256 females is 37.4. The mode for both sexes is 38.0 mm. (Fig. 2.)

The largest male examined has a total length of 101.5 mm., and the longest female, 107.0. Dunn (1926: 299) reported his longest male to be 115 mm. and his longest female, 105 mm. However, these specimens were collected at Ottawa, Canada, in the range of the formerly recognized race, *E. b. major*, where the salamanders are known to attain a larger size than in other populations of *Eurycea bislineata* in northern and central United States. Bishop (1941: 277) found in New York that males may attain a total length of 92 mm., and the females, 97. Oliver and Bailey (1939: 200) found in New Hampshire that the largest male had a total length of 88 mm., and the largest female, 93. Reynolds and Black (1936: 292) reported an individual with a total length of 104 mm. from Putnam County, Indiana. Unfortunately, Mittleman (1949) did not mention the size of *Eurycea bislineata rivicola* in the original description. These data indicate that *E. b. rivicola*,

TABLE II

AVERAGE MEASUREMENTS (IN MM.) AND PROPORTIONS OF *Eurycea bislineata rivicola*

A single male with a total length of 101.5 mm. has been lumped with the 90.0–99.5 mm. size class

Total length	Sex	N	Snout–vent length	Tail length	Tail length / Total length
40.0–49.5	♂	2	24.0	24.0	50.0
	♀	4	23.8	19.3	44.8
50.0–59.5	♂	16	28.3	28.0	49.7
	♀	12	27.3	27.0	49.7
60.0–69.5	♂	29	32.1	35.9	52.8
	♀	13	31.5	34.2	52.0
70.0–79.5	♂	59	34.2	39.5	53.6
	♀	30	35.5	39.9	52.9
80.0–89.5	♂	59	38.1	45.9	54.6
	♀	72	39.5	45.4	53.5
90.0–99.5	♂	17	41.8	52.3	55.6
	♀	43	42.2	51.7	55.1
100.0–109.5	♂	..	....	....	....
	♀	5	45.5	59.4	56.6

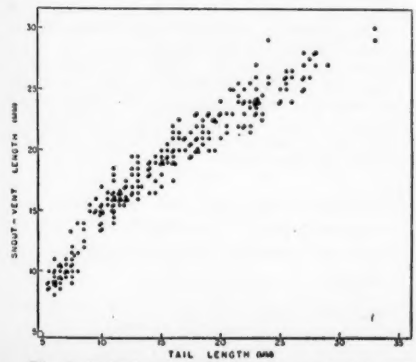

Fig. 3. Relative growth of body and tail in 243 larvae of *Eurycea bislineata rivicola*.

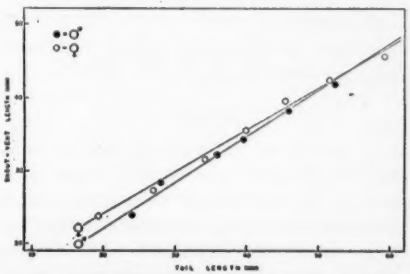

Fig. 4. Relative growth of body and tail in transformed (182 males, 177 females) individuals of *Eurycea bislineata rivicola*. Circles represent the means of the 10-mm. size classes. The lines were calculated by the method of least squares.

at least in southwestern Ohio, attains a greater length than *E. b. bislineata* does in New York and New Hampshire.

That there is heterogonic growth in salamanders is a well established fact. Usually the tail comprises a greater part of the total length in large individuals of a population than it does in the small ones. In the present study we have attempted to analyze the relative growth of the body and tail throughout the ontogenetic development.

In larvae with a snout–vent length of less than 17 mm. the tail comprises from 38 to 45 percent of the total length, usually about 40 percent. Larger larvae show a definite increase in the size of the tail over that of the body, and in the largest individuals the tail comprises 49 to 55 percent of the total length. The largest larval specimen has a total length of 62.0 mm., of which the tail makes up 53.2 percent (Fig. 3). At hatching, the tail comprises about 40 percent of the total length. The body and tail grow approximately at the same rate until the larvae reach a snout–vent length of 15 to 20 mm.; after that the tail increases in length more rapidly than does the body, and in individuals with a snout–vent length of approximately 25 mm. the tail comprises approximately 50 percent of the total length.

There is but slight evidence of sexual dimorphism in the tail length of transformed individuals. The smallest males have a tail/total ratio of 50 percent; the smallest females, 45 percent. The difference narrows in the larger individuals, and in the largest the females have a tail/total percentage that is slightly greater than that of the males. The tail length formula for the transformed males is *Tail length* = *1.6432*(*Snout–vent length*) − *16.789*; that for the females is *Tail length* = *1.7508*(*Snout–vent length*) − *21.678* (Table II; Fig. 4).

Summary

Seven hundred and eighty-one specimens of *Eurycea bislineata rivicola* Mittleman were studied. In southwestern Ohio, larvae hatch probably in late June, at which time they are slightly less than 9 mm. in snout–vent length. At the age of one year they have reached a snout–vent length of approximately 20.0 mm. Most of them continue to grow for another year, metamorphosing during their third summer with a snout–vent length of 23 to 32 mm.; however, some may metamorphose at a smaller size. Transformed specimens range in size from 22 to 48 mm. in snout–vent length and from 40 to 107 mm. in total length. During the early part of their development the larvae grow rapidly with the tail and body rates approximately similar. After the larvae reach a snout–vent length of 15 to 20 mm., the tail grows at a faster rate than does the body, so that at transformation the tail comprises approximately 50 percent of the total length. There is an insignificant sexual dimorphism in tail/total ratios in the transformed specimens. In small adults the males have the longest tails, while the largest females have a proportionately longer tail than do the largest males.

Literature Cited

Bishop, Sherman C. 1941. The salamanders of New York. *New York State Mus. Bull., 324: 365 pp.*

——— 1943. Handbook of salamanders. *Comstock Publishing Co., Inc., Ithaca, New York: xiv + 555 pp.*

Dunn, Emmett R. 1926. The salamanders of the family Plethodontidae. *Smith College Fiftieth Anniversary Publ.: viii + 441 pp.*

Mittleman, M. B. 1949. American Caudata VI. The races of *Eurycea bislineata*. *Proc. Biol. Soc. Washington, 62: 89–96.*

Oliver, James A., and Joseph R. Bailey. 1939. Amphibians and reptiles of New Hampshire (pp. 195–221), *in* Biological Survey of the Connecticut Watershed. *Surv. Rept. 4, New Hampshire Fish and Game Dept.: 1–256.*

Reynolds, A. E., and E. G. Black. 1936. The salamanders of Putnam County. *Proc. Indiana Acad. Sci. (1935), 45: 287–94.*

Weichert, Charles K. 1945. Seasonal variation in the mental gland and reproductive organs of the male *Eurycea bislineata*. Copeia (2): 78–84.

Wilder, Inez W. 1924. The developmental history of *Eurycea bislineata* in western Mass. Copeia, *133: 77–80.*

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Dimorphism in Larval Mouthparts in Spadefoot Toads of the *Scaphiopus hammondi* Group

GRACE L. ORTON

IN his recent discussion of the sporadic "beaked" variant in spadefoot tadpoles of the *Scaphiopus hammondi* group in western United States, Turner (1952) has concluded that differences in the contours of the larval beaks (= "mandibles") are not valid criteria for the separation of the three commonly recognized northern forms of the group, and that the structure of the beak does not change significantly between the approximately half-grown larval stage and metamorphosis.

Buccal dimorphism in larvae of western spadefoots has long been known and has been discussed briefly by several authors, of whom Turner appears to have been the first to treat the character on the basis of population samples from widely separated localities. The problem is somewhat more complicated than he has indicated, however, and it warrants much further study. Ideally, it should be worked out along with a thorough basic review of the systematics of the genus. The *hammondi* group is not yet adequately understood, and the broad overlap in the ranges of *S. h. hammondi* and *S. h. bombifrons*, as currently defined, is perhaps an important factor in the larval problem. The present paper reviews the background of the problem and discusses some of the lines of investigation that may help to provide a satisfactory solution.

Gilmore (1924) described dimorphic spadefoot larvae, referred to *S. hammondi bombifrons*, from the vicinity of Colorado Springs, Colorado. The larvae with hypertrophied mouthparts had markedly carnivorous habits. The beaks of these individuals were enlarged and thickened, the upper bearing a strong median cusp and the lower a pair of such structures separated by a deep notch. The jaw muscles were greatly enlarged, conspicuously modifying the contours of the head. This locality is near the Colorado limit of *bombifrons*, which is predominantly a Great Plains form, and is near the zone in which the ranges of *bombifrons* and *hammondi* are currently understood to meet or overlap (Turner, 1952, fig. 2; Wright and Wright, 1949, map 6; Stebbins, 1951, pl. 55). Smith (1934) quoted extensively from Gilmore, and described and figured the strongly cusped mouthparts of a carnivorous type of tadpole collected near Grant, Valencia County, New Mexico. No mention was made of the jaw musculature, but it was noted that the larvae had "small partially devoured tadpoles in their mouths," when collected. Smith contrasted these carnivorous larvae with specimens referred to typical *hammondi* by Storer (1925) and by Wright (1929), and concluded that the "differences are so marked that there can be little doubt of their specific value."

Tanner (1939) described tadpoles which he referred to the newly revived *intermontanus*. In these larvae the upper beak had serrated edges and a "median point," and the lower beak had a median notch which, however, lacked projections at its sides. He indicated that these specimens agreed more closely with *hammondi*, as described by Storer (1925), than with *bombifrons*, as described by Smith (1934).

From the vicinity of Las Vegas, New Mexico, within the region where the ranges of *hammondi* and *bombifrons* are now understood to overlap widely, Bragg (1941a, b) reported adults of both forms and larvae of two kinds, conforming respectively to the heavy-jawed type referred to *bombifrons* by Gilmore and Smith and to the thin-beaked type referred to *hammondi* by Storer and Wright. "During the breeding congresses," Bragg (1941a: 93) stated, "some pools contained only *S. hammondii*, some only *S. bombifrons*, and still others a mixture of the two species. In every case, the tadpoles later found conformed to expectations." Previously, he had found that in central Oklahoma adult spadefoots have the characters of *bombifrons*, whereas the larvae are uniformly of the thin-beaked type described by Storer and Wright for *hammondi*. Bragg apparently assumed that the larval differences are constant and wholly characteristic of the respective forms of *Scaphiopus*, as one would expect them to be. On the basis of his observations in both Oklahoma and New Mexico, he

concluded that the original identifications of larvae in this group of spadefoots had been confused and should be reversed: that the heavy-jawed form with prominent cusps on the beaks should be called *hammondi* and the thin-beaked form *bombifrons*. This change in larval identifications was accepted by Wright and Wright (1949) and by Smith (1950), and was tentatively followed by Stebbins (1951), who, however, cited exceptions in beak structure in larval samples of all three forms under consideration.

From variational data on nine scattered populations, Turner (*op. cit.*) concluded that the forms in the *hammondi* group are not separable on the basis of the mouthparts, for *hammondi* and *bombifrons* each may have a distinct median projection on the upper beak as a relatively uncommon modification, and the lower beak may be notched in all three forms. "Indeed, in certain samples, the variation within one population may be of the same magnitude as that which has been formerly supposed to differentiate subspecies. . . . That it [median cusp on upper beak] might be regularly present in a certain population or even within all populations in some areas is possible, however, and this may be the basis for the statements that it is a diagnostic character in *Scaphiopus h. hammondi*." Turner recognized, as Bragg apparently had not, that modified beak contours may characterize individuals rather than populations. Unfortunately, however, the specialized larvae on which Turner's observations and illustrations are based are actually only intermediates. He apparently did not have examples of the extreme variant with excessively hypertrophied beaks and jaw muscles on which Gilmore (1924) and Smith (1934) based their observations. The degree of enlargement of mouthparts is subject to wide variation in these larvae. So far as I know, the most extreme condition is that reported by Gilmore. I have examined some of his specimens in the collection of the University of Michigan Museum of Zoology (UMMZ).

Spadefoot larvae with greatly hypertrophied mouthparts have been reported from Colorado Springs, El Paso County, Colorado (Gilmore, 1924); Grant, Valencia County, New Mexico (Smith, 1934); and Las Vegas, San Miguel County, New Mexico (Bragg, 1941a, b). All of these localities are in or near the region of overlap in the ranges of *hammondi* and *bombifrons*, and the identification of individual larvae is thus somewhat open to question. I do not know of any published records of the extreme variant in additional localities, but one specimen of this type is included in a series of 21 spadefoot tadpoles from near Kadoka, Jackson County, South Dakota (UMMZ 76558–59). This locality is at or near the eastern limit of the range of *bombifrons* in the state, as mapped, and is far distant from the nearest known localities of *hammondi* and *intermontanus*. It thus constitutes a definite record of occurrence of the extreme variant in *bombifrons*.

Studies on larval dimorphism in the *hammondi* group should be extended to include Mexican populations of *hammondi* and *bombifrons*, and the southern representative of the group, *multiplicatus*, which occurs over the central and southern parts of the Mexican plateau, southward to Oaxaca. Taylor (1942) reported that tadpoles which he regarded as topotypic of *multiplicatus* (from El Guardia, southwest of Mexico City) showed no trace of cusps on the beaks. The University of Michigan collection contains two series of spadefoot tadpoles from different localities in San Luis Potosí, México. These larvae are of moderate size, about 20–45 mm. in total length. A series of 80 tadpoles includes one individual with exceptionally large jaw muscles, which retain the larval arrangement although the specimen is in an early stage of transformation and had already shed the beaks. In the second series, 5 of the 76 tadpoles have the jaw muscles somewhat enlarged and have a moderately developed median cusp on the upper beak and median notch on the lower beak. They have relatively wider lips, more sharply serrated beaks, and a flatter snout profile than do unmodified larvae in the same series. The specialized individuals are roughly intermediate in extent of modification. These two series of tadpoles are probably referable to typical *multiplicatus*, but whatever their eventual identification they are from localities geographically remote from the regions in which jaw hypertrophy has been reported previously, and they further demonstrate that this modification of the mouthparts is of very widespread occurrence.

Larvae with extremely modified beaks and enlarged jaw muscles and cartilages have, thus, been taken in several parts of the range of *bombifrons*, including the area in the southwest where the range of this form is now considered to overlap broadly that of *hammondi*, and in at least some populations both specialized and normal individuals occur together. Variously intermediate larvae, such as those described and figured by Turner, are known from widely separated populations in all three northern forms and in *multiplicatus*. The available evidence suggests the possibility that in the *hammondi* group in general there is an unstable trend toward overdevelopment of the mouthparts as a variant character, and that this trend may reach its extreme expression in *bombifrons*. The geographic and systematic limits of this variant, in all gradations of its expression, need to be determined more precisely. Breeding experiments could establish whether the jaw modifications have a definite genetic basis. Half-grown larvae can easily be identified to type, but so far as I know no one has traced the development of both types from hatching onward, to determine with certainty whether the differences appear during the formation of the mouthparts or whether there is divergence of structure after the feeding pattern of the individual has become established. It is theoretically possible that overdevelopment of the jaw region might follow secondarily ("excessive exercise") from a basic difference in individual feeding preferences, but it is also possible that the feeding pattern itself may be genetically determined. Ecological factors affecting the larvae should be studied more fully. The selective advantage of the polymorphic types, and consequently their numerical ratios, might differ from year to year in the same population. The unusual variability in mouthparts may itself be an important adaptive character, widening the limits within which a successful year-class might be obtained.

It would be instructive to make detailed comparative studies of larval food preferences and modes of feeding in the *hammondi* and *holbrooki* groups. "Cannibalism" has been reported in eastern *holbrooki*, but aggressive predation in contrast to simple scavenging on protein material is apparently not a normal feeding pattern in this form (Richmond, 1947), and so far as I know no evidence of buccal dimorphism has been found.

The tadpoles of relatively few species are known to have excessive enlargement and heavy muscular development of the mouthparts and associated carnivorous or aggressively predatory food habits. The examples are, however, well scattered taxonomically and geographically and are known from a variety of ecological situations. They include *Hoplophryne rogersi* (Microhylidae, Africa); *Ceratophrys dorsata* and *C. ornata* (Leptodactylidae, South America); the four Jamaican forms of *Hyla* (Hylidae); and the *Rana rugulosa* group (Ranidae, tropical Africa and southeastern Asia). In these forms enlarged and strengthened jaw apparatus appears to be a normal larval characteristic of the species rather than a sporadic variant. This is a striking difference from the condition in the *Scaphiopus hammondi* group, and leads one to speculate whether the variant larval type in the *hammondi* group may be undergoing an early phase of evolution, already widely distributed but perhaps still having a very low gene frequency in most populations. If the maximum expression of this variation should prove to be genetically characteristic of *bombifrons*, one could consider the possibility that in the broad area of overlap of the ranges of *bombifrons* and *hammondi* this character may, through introgression, be entering into stocks that are genetically *hammondi*.

The buccal dimorphism in the *Scaphiopus hammondi* group is an excellent example of the larval problems that are abundant in the amphibians and that require, for solution, application of the wide range of methods and resources now available to the systematist.

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Literature Cited

Bragg, Arthur N. 1941a. Tadpoles of *Scaphiopus bombifrons* and *Scaphiopus hammondii*. *Wasmann Coll., 4 (3): 92–4.*

——— 1941b. Some observations on amphibia at and near Las Vegas, New Mexico. *Great Basin Nat., 2 (3): 109–17.*

Gilmore, R. J. 1924. Notes on the life history and feeding habits of the spadefoot toad of the western plains. *Colorado Coll. Publ., Sci. Ser., 13 (1): 1–12.*

Richmond, Neil D. 1947. Life history of *Scaphiopus holbrookii holbrookii* (Harlan). Part

I: Larval development and behavior. *Ecol., 28 (1): 53–67.*

SMITH, HOBART M. 1934. The amphibians of Kansas. *Amer. Midl. Nat., 15 (4): 377–528.*

——— 1950. Handbook of amphibians and reptiles of Kansas. *Univ. Kansas Mus. Zool., Misc. Publ., (2): 1–336.*

STEBBINS, ROBERT C. 1951. Amphibians of western North America. *Univ. California Press: ix + 539.*

STORER, TRACY I. 1925. A synopsis of the amphibia of California. *Univ. California Publ. Zool., 27: 1–342.*

TANNER, VASCO M. 1939. A study of the genus *Scaphiopus. Great Basin Nat., 1: 3–20.*

TAYLOR, EDWARD H. 1942. Tadpoles of Mexican anura. *Univ. Kansas Sci. Bull., 28 (3): 37–55.*

TURNER, FREDERICK B. 1952. The mouth parts of tadpoles of the spadefoot toad, *Scaphiopus hammondi.* COPEIA *(3): 172–5.*

WRIGHT, ALBERT H. 1929. Synopsis and description of North American tadpoles. *Proc. U. S. Nat. Mus., 74 (11): 1–70.*

———, AND ANNA A. WRIGHT. 1949. Handbook of frogs and toads of the United States and Canada. *3rd ed. Comstock Publ. Co.: xii + 640.*

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Variation in a Large Litter of Gartersnakes, *Thamnophis sirtalis sirtalis*

BERNARD MARTOF

AN extraordinarily large specimen of the common gartersnake, *Thamnophis s. sirtalis* (Linnaeus), was captured on July 24, 1948 near the Eber White Woods immediately west of Ann Arbor, Washtenaw County, Michigan. In total body length it measured 110.5 cm. (a size very close to the maximum, 111.8 cm., reported for this species by Conant, 1951). This specimen was in excellent condition, docile, easy to handle, but it did not feed while in captivity even though a wide selection of food items was offered: fishes, frogs, earthworms, ground beetles, mice and birds. The last two items are not regularly a part of the diet of the gartersnake; however, they were offered when the snake did not eat more preferred items.

On August 6, 1948 this specimen gave birth to a large litter. The first of its young was born at 6:45 AM and the last at 4:25 PM, about 9 hours and 40 minutes being required for the birth of the litter. No record was kept of the rate at which the young emerged; however, throughout the entire period of parturition the parent remained rather quiet as irregularly timed contractions moved along her body. As these contractions, which were seen as distinct constrictions, neared the posterior end of the animal, its tail was elevated and the young emerged. With each wave of contraction one to three, usually two, young were discharged. When the young emerged, most were enclosed in the delicate, transparent amnion, which soon broke, permitting the occupant to escape. All snakes were preserved soon after birth.

This snake gave birth to 85 offspring. As far as I can ascertain from the literature, this is the largest litter known for the species. Ruthven *et al* (1928) reported a litter of 78 gartersnakes, but unfortunately no details were given. Of the 85 young, 78 were active and alert, whereas seven were dead at birth. Those dead were obviously anomalous individuals. Because of the difficulty involved in making counts of scales and measurements of these aberrant, and some even partly disintegrated, young, most of the data which follow pertain to the 78 living young. The seven snakes that were dead at birth will be described later. In view of the criteria used in keys to the species of snakes, the amount of variation present in this litter is surprisingly great. In fact, much of the variation reported for *T. s. sirtalis* as a whole is present.

The sex of the offspring was ascertained by observation of the base of the tail. The tail of the male has an even taper throughout its entire length; that of the female tapers rather rapidly for a short distance behind the cloacal opening but farther back the tapering becomes more regular as in the male. The change in the rate of taper is due to the large musk glands which in the female extend about 4 mm. posteriorly from the cloaca. In addition these yellow glands are easily visible through the

subcaudal scales (Fig. 1). The musk glands of males are not visible externally.

All specimens, whose sex was not positively ascertained by external observation, were dissected for verification. In addition, occasional check dissections were made on those whose sex was determined by external observation. No discrepancies were noted. Of the 78 living offspring, 40 were males and 38 were females. Of the seven dead specimens, three females and two males were identified, but it was impossible to ascertain the sex of the other two. Thus in this litter the ratio of the sexes was practically 1:1.

Measurements of each specimen were made by placing it upon the flat surface of a ruler. Next, the snake was carefully straightened, but not stretched, along the ruler and the snout-to-vent and total body lengths were taken.

In regard to total length, the male offspring were usually longer than the female. The 40 living males averaged 184.2 mm. and ranged from 152 to 197. The 38 females had an average length of 177.9 mm. and a range of 150 to 191. I think that this difference is notable because the largest adult specimens on record are females. Accordingly, it is suggested that there is sexual dimorphism in the rate of growth.

The snout-to-vent measurements for the sexes were more alike than those of total body length. The males averaged 141.2 mm. and ranged from 118 to 151; the females averaged somewhat less, 139.5 mm., although the range was almost exactly the same: 117 to 151 mm.

Tail length was obtained by subtracting the snout-to-vent measurement from the total length. The males averaged 43.0 mm. in length of tail with a range from 34 to 46; the females averaged only 38.2 mm. and ranged from 33 to 42. Thus, male and female gartersnakes are born with almost the same snout-to-vent measurements but the males have definitely longer tails. Accordingly the ratio of the tail length to the total body length is greater for males than for females. For the males this ratio averaged 23.3 percent, range 22.1 to 24.9; for the females the average was 21.4, range 20.4 to 22.9. The parent, however, had a ratio of 19.9 percent. The values for my young snakes are in agreement with those reported for adults by Conant (1951): his males averaged 23.8 percent and ranged from 23 to 25; his females averaged 20.8 and ranged from 18 to 24. Therefore, it seems probable that the same general proportions of tail and body are maintained throughout life.

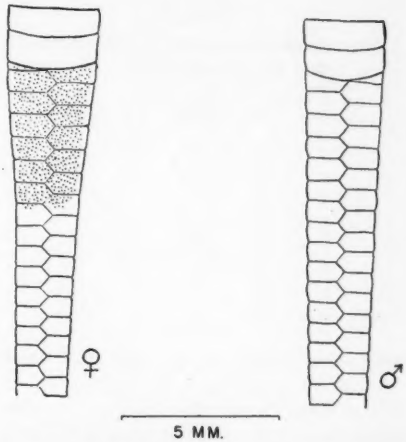

Fig. 1. Sexual dimorphism in base of tails of newborn gartersnakes. Stippled area indicates underlying musk glands of female.

I think that a more desirable way to indicate sexual dimorphism in snakes would be to compare the tail length with the snout-to-vent measurement rather than with the total length. In comparing the tail with the total body length, the tail is in part compared with itself (Such a ratio is presented in this paper so that a comparison could be made with records already in the literature). For the males the ratio of the tail length to the snout-to-vent measurement averaged 30.4 ± 1.0 percent and ranged from 28.2 to 33.1; the females averaged 27.4 ± 0.9 and ranged from 25.5 to 29.1. The number of individuals in the region where the ranges of the males and females overlap is only 10. By making a comparison of the tail and total body lengths, 16 specimens were included in the region of overlap.

The umbilical scar is generally shown by a midventral furrow which may extend over as many as 24 ventral scales but usually is evident on about eight. However, the major portion of the umbilicus, i.e., the part through which bodily tissue can be seen, is confined to two or three ventrals. The central portion of this bodily tissue is interpreted to be the location of the umbilicus. It is about 90 percent of the distance from the tip of the snout to the anal

TABLE I

DISTRIBUTION OF DIVIDED VENTRAL SCALES AMONG THE OFFSPRING BORN ALIVE

Number of divided ventrals	Females	Males
0	32	32
1	4	4
2	1	2
3	..	1
4	1	..
5	..	..
6	..	1

TABLE II

DISTRIBUTION OF INCOMPLETE VENTRAL SCALES AMONG THE OFFSPRING BORN ALIVE

Number of incomplete ventrals	Females	Males
0	32	33
1	3	4
2	2	2
3	..	..
4	..	1
5	1	..

plate. More exactly, for the males this value is 89.4 ± 1.02 percent and for the females it is 89.0 ± 0.99. The difference between the values obtained for males and females is statistically insignificant at the 5 percent level (obtained by the method outlined in Kenney, 1939: 140).

Edgren (1951) reported that for *Heterodon platyrhinos* the location of the umbilicus is a secondary sexual characteristic. He said that "The actual range for the anterior end of the scar in males varies from ventral 98 to ventral 108; in females from 107 to 120. The posterior end varies from the 99th ventral to the 111th in males and from the 109th to the 123rd in females." A similar variation of the position of the umbilicus exists among the gartersnakes of this litter but a different interpretation is offered. In *T. s. sirtalis* the status of the sexes is opposite to that found in *H. platyrhinos*. The anterior end of the umbilicus in males varies from ventral 129 to 143, in females from 125 to 135. The posterior end varies from 132 to 144 in males and from 128 to 137 in females. The centers of the umbilicus, on the average, are located at the 137.7th ventral in males and the 132.7th in females. The difference between the above averages is almost exactly the difference between the average number of ventrals in the males and females. The females have from 146 to 156 ventrals, average 149.1, while the males range from 151 to 159 ventrals, average 154.0. Therefore the difference in the position of the umbilicus, as indicated by the ventral scales, is not another sexual difference but actually is an expression of the well established fact that the number of ventrals is diagnostic of sex in many species of snakes.

With regard to ventral scales, perhaps it is necessary to explain how certain anomalous conditions were considered. Divided scales, which join near the mid-ventral line and together make the equivalent of a single typical ventral, were, of course, counted as one. Four such scales occurred in the parent. Only one offspring had four, another had six and all others had less, in fact 82 percent had no divided ventrals (Table I).

Incomplete ventrals, those which did not extend all the way across the ventral part of the body, were preceded and followed by average-sized scales and therefore were not included in the tallies of ventral scales given earlier in this report. The parent and 83 percent of the young had no incomplete ventral scales but among the others as many as five such scales occurred (Table II).

Associated with the longer tails of the male offspring were larger numbers of subcaudal scales. The average number of subcaudals for the males was 71.4, the range 67 to 75. The females averaged 61.5 and ranged from 58 to 69. Only one female, but 11 males, were in the region of the overlapping of ranges.

All offspring and the parent had a single loreal scale on each side, a single preocular on each side, a single undivided anal plate, and two anterior and two posterior gular scales. In having three rostral scales the parent differed from its offspring, all of which had one. The parent was also unique in that it possessed two prenasal and two postnasal scales on the right side of its body, a condition shared in part by only one of its offspring (born dead) which had two right prenasals. All specimens had but one prenasal and one postnasal scale on the left side. A single anterior temporal was present on the parent and on most young; but one living (at birth) and one dead offspring had two anterior temporal scales on each side and

TABLE III

DISTRIBUTION OF UPPER LABIAL SCALES AMONG THE OFFSPRING BORN ALIVE

Number of upper labials, Right-Left	Females	Males
8–8	5	2
8–7	3	1
7–8	1	..
7–7	29	37

another specimen which was alive at birth had two anterior temporal scales on the right side only.

The usual number of upper labial scales for this species is 7, but occasionally 8 and rarely 6 occur (Conant, 1951). The parent had 7 upper labials on the right side of its head, but had 8 on the left side. Among the offspring, more females than males (21.5 as compared to 7.5 percent) had 8 upper labials on one or each side (Table III); however, about 85 percent of the young had 7 upper labials on each side.

There is an obvious tendency for the male offspring to have a smaller number of lower labial scales than do the females. About 74 percent of the females had 10 such scales on each side (the usual number of the species) but only about 58 percent of the males possessed that number. The bimodal distribution of these scales (Table IV) suggests that possibly the male parent had nine scales on at least one side of its jaw.

The parent and most of its young (77 percent) had three postocular scales on each side

TABLE IV

DISTRIBUTION OF LOWER LABIAL SCALES AMONG THE OFFSPRING BORN ALIVE

Number of lower labials, Right-Left	Females	Males
11–12	1	..
11–10	2	1
10–11	4	1
10–10	28	23
10–9	2	2
9–11	..	1
9–10	..	4
9–9	..	5
9–8	1	2
8–9	..	1

TABLE V

DISTRIBUTION OF POSTOCULAR SCALES AMONG THE OFFSPRING BORN ALIVE

Number of postoculars, Right-Left	Females	Males
4–4	1	2
4–3	1	1
3–4	3	2
3–3	31	29
3–2	2	1
2–3	..	3
2–2	..	2

of the body; however, some offspring had four on each side and others had only two (Table V).

None of the offspring had 21 scale rows, a condition reported by Conant (1951); however, some snakes with 20 scale rows over small portions of the body were noted. Supernumerary scale rows occurred in 7 of the 78 offspring which were born alive. Of these seven, six were females. An average of 6.1 (range from 3 to 11) scales were present between the 4th and 5th scale rows and between the 30th and 61st ventrals. All the other offspring and the parent had 19 scale rows over the anterior part of the body.

The mid-dorsal scale row extended caudally to near a point above the anal plate. In the parent it terminated 3 scales in front of this point, while in the offspring it ended, on the average, 1.5 scales in front, ranging from 7 scales anterior, to 4 posterior to the anal plate. No sexual dimorphism was indicated here.

In the parent the 4th scale row dropped out at the 86th ventral on the right side but on the left it continued to the 92nd. Among the offspring a similar but less striking tendency for the 4th row to persist farther back on the left side was noted. On the right side, the 4th scale row dropped out between the 67th and 108th ventrals, average 86.7; and on the left side, the 4th row ended between the 70th and 105th ventrals, average 88.2.

There is much variation in the manner that scale rows were lost. Generally, the scales of the 4th row became obviously smaller near the end of the row, while those of the 3rd and 5th rows were of uniform size, their keels forming straight lines. However, in about one-third of the specimens both the 3rd and 4th rows contained smaller-than-usual scales near the site

where a scale row was lost. Then abruptly a scale row started between them. Moreover, in two specimens a large double-keeled scale occurred at the place of junction of the 3rd and 4th scale rows. Sometimes when the 4th scale row ended and adjacent rows were continuous, from one to three scales, obviously a part of the 4th row, were located two to four scales caudad. The number of these scales present was added to the ventral count for the end of the continuous part of the 4th row and the termination of the row was indicated as the sum. Possibly it would be better to interpret the scale row as ending where the last scale was located, in spite of the intervening gap; however, since only 5 instances were noted, I thought that the data would not be altered greatly.

The smallest of the snakes in the litter was 67 mm. in total body length. This animal was almost overlooked for it was encased in a mass of yolk about the size of an average gartersnake's egg. This tiny snake (Fig. 2) is of additional interest because of the abnormal morphology of its head. The cranium is of proper length but is definitely malformed. The obviously atypical lower jaw is greatly enlarged and would be more fitting for a snake about 100 mm. in total length. Scales were absent over the head of the snake and possibly this may account for the mal-shaped cranium. The only places where scales could be seen distinctly were on the lateral surfaces of the animal. Ventral scales had apparently started to form; this is indicated by shallow grooves. The dorsum of this snake was deeply segmented and devoid of scales.

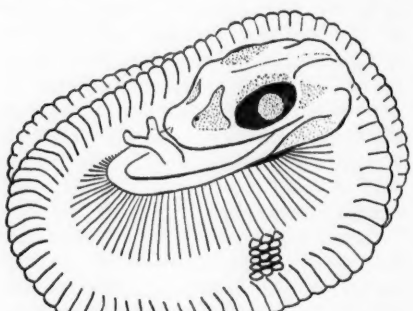

Fig. 2. Diminutive gartersnake with mal-proportioned head and incomplete scale formation.

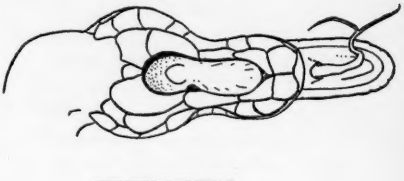

Fig. 3. Anomalous head of new-born gartersnake having no eyes, an elongated lower jaw, and a partly extruded brain. Dorsal view.

One other anomalous specimen has an elongated lower jaw but, unlike the above-mentioned snake, this one was of average size and its scales were fully developed. It is especially outstanding because of its lack of eyes and because of the large opening in the top of its head (Fig. 3). From this opening tissues of the brain extruded and passed anteriad over the snout. Where they overlaid the skin, no scale formation occurred. The head of this animal was soft, i.e., no bone formation was present in the cranium.

A rare accident which occurs in the development of monovular twins is conjoined double monsters. A two-tailed monster was present in this litter which suggests the *duplicitas posterior* condition described by Patten (1946) wherein extensive fusion results in the complete mergence of the anterior parts of the body; only the posterior parts remain separate.

Another feature of atypical development was also represented (Fig. 4). One specimen had a deep transverse depression across the skull im-

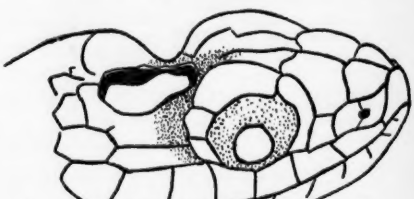

Fig. 4. Head of gartersnake with deep groove behind eyes and opening through which brain bulged.

mediately posterior to the eyes. In the middle of this depression was a large opening through which the brain bulged. The other three stillborn snakes had openings in the dorsal part of their heads through which their brains either bulged or were partly extruded. Bone formation was lacking in their crania. One also had a transverse groove over the posterior part of its head.

Summary

A large gartersnake gave birth to 85 offspring, 78 of which were born alive. Of the specimens in which sex could be determined, 42 were males and 41 females.

The sex of new-born gartersnakes can be ascertained by examination of the base of the tail. In females large musk glands are easily seen; in males they are not visible externally.

Male offspring were longer in total length than were the females. The difference is due primarily to the longer tails of the males. This sexual dimorphism in general body proportions is best indicated by the ratio of the tail length to the snout-to-vent measurement.

Sexual dimorphism was also shown by the number of ventrals, hence by the position of the umbilicus among the ventral scales. Furthermore, the males had more subcaudal scales than did the females.

Much variation but no definite sexual dimorphism was indicated among the offspring by the number of upper labials, lower labials and postoculars and by the location of the posterior ends of the 4th and mid-dorsal scale rows.

All the specimens that were dead at birth were obviously anomalous. One was about one-third average body length and lacked scales except over the lateral surfaces of its body. All showed atypical development of the head. Some of the conspicuous deformities were: (1) lower jaw elongated, extending far beyond the upper jaw; (2) lack of bone formation in the head; (3) an opening located posterior to the eyes and through which the brain bulged or extruded; and (4) a transverse furrow immediately behind the head. One snake was eyeless and another had two tails.

Literature Cited

Conant, R. 1951. The reptiles of Ohio. *Univ. Notre Dame Press, Notre Dame, Indiana: 284 pp.*

Edgren, R. A. 1951. The umbilical scar, a sexually dimorphic character in *Heterodon platyrhinos. Nat. Hist. Misc., 83: 1–2.*

Kenney, J. F. 1939. Mathematics of statistics. Part II. *D. Van Nostrand Co., New York: ix + 201.*

Patten, B. M. 1946. Human embryology. *Blakiston Co. Philadelphia: iv + 776.*

Ruthven, A. G., C. Thompson, and H. T. Gaige. 1928. The herpetology of Michigan. *Michigan Handbook Ser., 3: ix + 229.*

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Identification of the Amphibia and Reptilia Recorded in Jamaica by Hans Sloane (1688–89)

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On the occasion of the bicentenary of the death of Sir Hans Sloane (1660–1753), it is fitting to recall the contribution to herpetology made by this eminent physician and man of science, to whose learning and foresight we owe the very conception and foundation of the British Museum.

It is perhaps fortunate that, towards the end of 1687, while still a young man, Sloane had the opportunity of visiting the West Indies as physician to the Duke of Albemarle, who was then Governor of Jamaica; for, although his visit to those islands lasted only fifteen months, he thus acquired an experience in natural history which was the foundation of his life work, and was introduced to the hobby of collecting as a method of advancing knowledge.

During this voyage, Sloane assembled a botanical collection which is said to have included some 800 new species of plants, and it is in Jamaica that he made his herpetological observations. The results of his voyage were

published, in two large volumes, some years after his return to England (Sloane, 1707, 1725), and complete references to the passages, in this vast work, which are of herpetological interest are given in the bibliography at the end of the present paper.

Sloane (1725: 331–6, 395; pl. 273–4) recorded 16 species or varieties of Jamaican amphibians and reptiles, viz., Salientia, 1; Testudines, 4; Crocodilia, 1; Sauria, 7; and Serpentes, 3. These species are here identified, according to modern systematic nomenclature, so far as this has been possible from Sloane's original descriptions and illustrations of the herpetological fauna of Jamaica in the latter part of the seventeenth century. The species are considered in the order in which they were recorded, and, where relevant, references are provided to more recent records and observations on Jamaican herpetology, and particularly to those by Gosse (1851), Barbour (1910, 1914, 1937), Grant (1940), and Lynn and Grant (1940).

Salientia

1. "Rana arborea maxima" (Sloane, 1725: 331). *Hyla septentrionalis brunnea* (Gosse). Tree-frog. Barbour (1937: 94), Lynn and Grant (1940: 6, 19).

   Hyla brunnea Gosse (1851: 361). Barbour (1910: 288, 1914: 239), Grant (1940: 152).

Sloane noted that "these Tree Frogs are very frequent in the woods of Jamaica, where they make a great noise in the night"; and Lynn and Grant (1940: 6) stated: "One may conclude with some assurance that this description refers to the common Jamaican hyla, . . . which thus has the honor of being the first native Jamaican amphibian to be mentioned in print."

Testudines (Testudinata)

2. "The Land Tortoise" (Sloane, 1725: 331). *Testudo denticulata* Linné.

   Testudo tabulata Walbaum.

Sloane found that a land tortoise was "common in the woods between Guanaboa and Town every where." He identified it with a species from Brazil described by Ray (1693) as follows: "Testa nigra est, cui multae figurae hexagonae insculptae. . . . Caput & crura fusca, verùm maculis ex umbra variegata." Browne (1789) also referred to "The Hicatee or Land Turtle" in Jamaica: "Major oblonga, testâ profundiori. . . .This species is a native of the mainland, but frequently imported to Jamaica, where it is often common. The shell is very deep, and often above a foot and a half in length; but the surface is generally divided into oblong hexagons, yellow in the center, and radiated with slender even streaks from thence to the circumference."

Gosse (1851: 421–5) stated: "Some of the older writers mention, among the animals of Jamaica, a Tortoise, to which they assign the name Hicatee. As they distinguish it from the Marsh Turtles, we may consider it to have been a true terrestrial species . . .; but whether actually indigenous or imported is doubtful." He quoted a report, in 1846, of "two more instances of Land Tortoises being taken under such circumstances as would lead to the supposition that they were indigenous. . . . They were both of good size, being . . . about thirteen or fourteen inches in length, measured over the carapace." He added, however, that "no clue to the specific identity of these specimens now remains."

Whether this Jamaican tortoise was, in fact, once indigenous, or whether it was introduced from South America, it would seem likely from the various descriptions that it was *T. denticulata*. According to Boulenger (1889), the distribution of this species is "tropical South America east of the Andes; Windward Islands." Duméril and Bibron (1835: 89) identified the Hicatee of Browne with the same species, and gave its distribution as "l'Amérique méridionale et les grandes îles des Antilles." However, they also described (1835: 99) as a separate, but closely related, species (*T. carbonaria*) having the same distribution, what is, presumably, the melanistic phase of *T. denticulata* (as would appear to be the case with Ray's species); and they stated that this dark variety is particularly common in Brazil, and is also found at Cayenne and in Jamaica (although no authority is given for this statement).

Grant and De Sola (1934) believed that *T. denticulata* "is endemic to the West Indies as it has been known from early times and has been taken alive and feral in the Virgin Islands. . . ." Barbour (1934), however, criticising the work

of these authors, stated that "there is not yet evidence of any value whatsoever to show that *Testudo* ever occurred wild in Cuba or in Jamaica or in Guadeloupe or, indeed, in any of the West Indian Islands except one or two small islets in the Virgin group. . . ." He observed elsewhere (Barbour, 1937: 163) that this species is "carried from time to time, to most of the islands from South America," but is "not a native element of the Antillean fauna."

If, indeed, it is true that, in Sloane's day, the melanistic phase of *T. denticulata* was particularly common in Jamaica, whether the species was originally endemic or introduced, this would, in either case, provide a further interesting example of the tendency so frequently shown by reptiles towards insular melanism (Mertens, 1934).

3. "Testudo marina vulgaris" (Sloane, 1725: 331).

Chelonia mydas (Linné). Green turtle.

Sloane (1707: lxxxviii) stated that these turtles "come to Caymanes, two small isles west of Jamaica, once a year to lay their eggs in the sand, to be hatch'd by the sun. . . . At other times they go to the South-Cayos off of Cuba; there to feed on the sea-grass growing under water."

4. "Testudo marina Caouanna dicta" (Sloane, 1725: 331).

Caretta caretta (Linné). Loggerhead turtle.

Sloane (1725) stated that this species was "as common in these Seas" as the green turtle, but erroneously named it "The Hawks-Bill Turtle." Yet, in another passage (Sloane, 1707: lxxxviii), he correctly recorded that "there is a sort of Loggerhead Turtle . . . at Jamaica, very little differing from the common sort [*Chelonia mydas*], only in every part less."

5. "Testudo Caretta dicta" (Sloane, 1725: 332).

Eretmochelys imbricata (Linné). Hawksbill turtle.

Sloane noted that "these are chiefly valued for their scales, commonly call'd Tortoise Shell."

It is an unfortunate source of confusion, that Linné (1758) should have given the name *Testudo caretta* to the loggerhead turtle; and it is evident from his references, that he did so under the erroneous impression that the species which he described was identical with that named "Testudo Caretta" by Ray (1693) and by Catesby (1743), whereas both of these earlier descriptions referred to *E. imbricata*.

Although, in his revised (12th) edition of the *Systema Naturae*, Linné (1766) to some extent corrected his earlier error, and correctly identified the species which he described as *Testudo imbricata* with the "Testudo Caretta" of Ray (1693) and the "Caret" of Dutertre (1667), he still erroneously regarded the "Testudo Caretta" of Catesby (1743) as synonymous with the species which he himself named *Testudo caretta*, (i.e., the loggerhead turtle).

The name "Caret" was, in fact, invariably applied to the hawksbill turtle by the French writers on the Antilles, in the 17th and 18th centuries (Dutertre, 1667; Rochefort, 1681; Labat, 1722), and it is still by this name that this species is known in France today.

Indeed, it is difficult to understand how Linné could have confused these marine turtles, insofar as they were quite clearly described and differentiated, not only by the French authors mentioned above, but by several other writers before him, such as Ray (1693) and Catesby (1743), with whose works he was acquainted. In particular, Catesby's illustration of the hawksbill turtle clearly shows the imbricated scales.

The following list gives the nomenclature which was applied to these three species of marine turtles by various writers of the 17th and 18th centuries:

Chelonia mydas
Testudo mydas Linné (1758).
Testudo marina, vulgaris: Ray (1693).
Tortuë Franche: Dutertre (1667), Rochefort (1681), Labat (1722).
Testudo marina viridis, The green Turtle: Catesby (1743).

Caretta caretta
Testudo caretta Linné (1758).
Testudo marina Caoüanna dicta: Ray (1693).
La Caoüanne, la Kaoüanne: Dutertre (1667), Rochefort (1681), Labat (1722).
Testudo marina Caouanna, The Loggerhead Turtle: Catesby (1743).

Eretmochelys imbricata
Testudo imbricata Linné (1766).
Testudo Caretta dicta: Ray (1693).
Le Caret: Dutertre (1667), Rochefort (1681), Labat (1722).
Testudo Caretta, The Hawks-bill Turtle: Catesby (1743).

CROCODILIA

6. "Lacertus omnium maximus, Crocodilus dictus" (Sloane, 1725: 332).

Crocodilus acutus Cuvier. American crocodile. Gosse (1851: 398), Barbour (1937: 166), Lynn and Grant (1940: 129).

Crocodilus americanus Cope. Barbour (1910: 301; 1914: 346).

Sloane stated that crocodiles were "very common on the coasts and deep rivers of Jamaica." He had occasion to make some observations (Sloane, 1725: 332, 346) concerning the anatomy of this species, which, in view of their historical interest, have been the subject of a separate paper (Ahrenfeldt, 1953).

Sloane (1725: 395) observed that the flesh and eggs of these reptiles "smell of musk so much, so as not to be good food." He also recorded (1725: 332) that a crocodile "nineteen feet in length . . . was taken by a dog, which was made use of as a bait, with a piece of wood ty'd to a cord," and stated (1707: lxxii) that "Allegators love dogs extreamly, but prey also on cattle."

SAURIA

7. "Lacertus Indicus senembi & Iguana dictus" (Sloane, 1725: 333, pl. 273).

Cyclura collei Gray. Iguana. Barbour (1914: 298; 1937: 132), Lynn and Grant (1940: 97).

Cyclura lophoma Gosse (1851: 76). Barbour (1910: 293).

Sloane observed that these iguanas were "very common in Jamaica." In recent times, Barbour (1937) noted that they were "almost extinct."

8. "Lacertus major e viridi cinereus, dorso crista breviori donato" (Sloane, 1725: 333, pl. 273).

Anolis garmani Stejneger. Venus lizard. Barbour (1910: 294; 1914: 273; 1937: 119), Grant (1940: 154), Lynn and Grant (1940: 83).

Dactyloa edwardsii Gosse (1851: 142).

This lizard, according to Sloane, was "found frequently in the woods of Jamaica. . . . It lays eggs less than a pigeon's egg."

9. "Lacertus major cinereus maculatus" (Sloane, 1725: 333, pl. 273).

Ameiva dorsalis Gray. Ground lizard. Gosse (1851: 74), Barbour (1910: 298; 1914: 309; 1937: 144), Lynn and Grant (1940: 109).

Ameiva sloanei Duméril and Bibron. (L'Améiva de Sloane).

Sloane stated that this lizard was "very common about old walls." According to Barbour (1937), it was "formerly abundant; then, after the mongoose came, pretty well reduced – almost exterminated."

Duméril and Bibron (1839: 107), describing this species from specimens obtained from Jamaica, observed that the figure given by Sloane "is truly excellent for the period at which it was published, and from which dates our knowledge of Sloane's Ameiva, which we have so named in honor of the memory of a learned voyager and friend of the Sciences."

10. "Lacertus cinereus minor" (Sloane, 1725: 333, pl. 273).

Anolis opalinus Gosse (1851: 217). Pearly-bellied anolis. Barbour (1910: 296; 1914: 282; 1937: 131), Grant (1940: 154), Lynn and Grant (1940: 92).

Sloane stated that this lizard "loves moist places and stones." According to Barbour (1937), it is now "a rather rare, woodland species, most often seen in western Jamaica."

11. "Lacertus minor laevis" (Sloane, 1725: 333, pl. 273).

Mabuya sloanei (Daudin). Barbour (1910: 299; 1914: 320).

Mabuya agilis Gosse (1851: 75).
Mabuya fulgida Cope. Grant (1940: 157).
Mabuya spilonotus Wiegmann. Lynn and Grant (1940: 111).
Scincus sloanii Daudin. (Le Scinque Sloanien).
Eumeces sloanii Duméril and Bibron. (L'Eumèces de Sloane).

This lizard was recorded by Sloane as "laying a very small white hard shel'd egg . . . and nestling in rotten holed trees, leaping from one bough to another. 'Tis very common among old palisadoes, etc." However, Barbour (1910) observed that this species, "which is known to the negroes by the quaint name of 'snake-waiting boy,' is now one of the rarer members of the island fauna. . . . The native name is

Fig. 1. Sloane's original figure of *Mabuya sloanei*. (By courtesy of the Trustees, British Museum.)

given to them because of the supposition that they follow snakes, as the jackal is often spoken of as the lion's follower."

In the original scientific description of the species, Daudin (1802) stated: "I have named this species *scinque sloanien*, because it has so far been observed only by Hans Sloane, who gave a very exact figure of it [Fig. 1], in his work on the Natural History of Jamaica." Duméril and Bibron (1839; 639), redescribing this skink under the name *Eumeces sloanii*, similarly wrote that they wished thus to commemorate "a learned voyager to whom we owe its discovery."

12. "Salamandra minima, fusca, maculis albis notata"; "The Wood Slave" (Sloane, 1725: 334, pl. 273).

Sphaerodactylus argus argus (Gosse). Barbour (1937: 114), Grant (1940: 153), Lynn and Grant (1940: 70).

Sphaerodactylus argus Gosse (1851: 76, 284). Barbour (1910: 292; 1914: 263).

Sloane stated that this lizard is to be found in old, rotten timber. It is described by Barbour (1937) as "an excessively common species."

Barbour (1910: 291), referring to the related species, *S. goniorhynchus* Cope (*S. gilvitorques*), observed that the latter "is sometimes called 'wood slave' or 'little wood slave' by the natives, though more generally by the name mentioned for *S. argus*," viz., "pawley lizard" or "water lizard," which, it is interesting to note, is applied to a species described by Sloane as "Salamandra." Barbour added that "the name of 'wood slave' is a very old one, occasionally applied to *Mabuya sloanei*, for which the name 'snake-waiting boy' is now more common." Gosse (1851: 75) identified the "wood slave" with *M. sloanei*.

13. "Scincus maximus fuscus"; "A Galliwasp" (Sloane, 1725: 334, pl. 273).

Celestus occiduus occiduus (Shaw). Grant (1940: 155), Lynn and Grant (1940: 108).

Celestus occiduus (Shaw). Gosse (1851: 77), Barbour (1910: 297; 1914: 304; 1937: 139).

According to Sloane, this species was to be found in "marsh grounds, in several parts of the Island." He noted that "it feeds commonly on the smallest sort of sea crabs," and that "it is reckon'd very poisonous in the bite, and I was told one had his thigh bit by this creature and dy'd the next day." Gosse merely identified the "yellow Galliwasp" with *C. occiduus*, and stated that it is to be found "in the swamps and morasses of Westmoreland."

Barbour, who has provided such interesting material on the native names for various reptiles, remains disappointingly silent as to the existence and possible significance of this lizard's strange and intriguing native name, which has also been written as "gully asp," "yellow wasp," etc. (Lynn and Grant, 1940).

Duméril and Bibron (1839: 590), describing *C. occiduus* (*Diploglossus shawii*), expressed some doubt as to the identity of this species with "the large Scincoid which Sloane has described and figured under the name of Galli-Wasp, in the account of his voyage to Jamaica," but considered that the latter was possibly some closely related species. Boulenger (1885), however, identified Sloane's "Scincus" with this species (*Diploglossus occiduus*).

Barbour (1937) noted that this was "a form which was once common and of which old adults reached a great size. . . . No such giants now occur and the species is rare." Grant (1940) stated that "the giant form . . . has probably been extirpated by the mongoose."

Serpentes

14. "Serpens major subflavus"; "The yellow Snake" (Sloane, 1725: 335, pl. 274).

Epicrates subflavus Stejneger. Yellow boa, Jamaica boa, ("Nanka", "yellow snake"). Barbour (1910: 300; 1914: 324; 1937: 151), Grant (1940: 157), Lynn and Grant (1940: 116).

Chilabothrus inornatus Gosse (1851: 314).

Sloane stated that these snakes were "for the most part to be found in the woody mountains, quoil'd up in the paths as ropes in a ship. They are not hurtful, unless irritated; they will not bite, except when they have their young near them, for their defence. The bitings very rarely prove mortal, although sometimes the wounds are very much swell'd and inflam'd, prove tedious in curing . . . ," i.e., become septic. In this connection, Lewis (1949) observed: "The bite of the Yellow Snake carries no poison, but it must be said that this reptile bites freely and can inflict a painful wound because the teeth, which are sharp and fragile, often break in the wound. The points of these teeth slant backwards, enabling the snake to take a firm grip on its victim, and making it difficult for the snake to release its hold once its teeth are clamped into the flesh."

Sloane (1725: 355) noted that many of these snakes "have been kill'd with thirteen or fourteen rats in their bellies," and remarked (1725: 346): " 'Tis upon this account that the European nations inhabiting the countries producing sugar, do not molest these creatures, because they destroy the rats . . . [which] multiply strangely there and do infinite mischief to the sugar canes, not only by eating them, but spoiling the juice of those they gnaw." The early European settlers apparently had more sense than those who, later, introduced the mongoose to the islands. Lynn and Grant (1940) stated that "these snakes are very beneficial inasmuch as rats form a major item of their diet."

Sloane (1725: 395) described the eggs as "membranaceous, like to goose eggs, hanging to one another by a membrane," and observed that "the young ones were . . . of several colours, six inches long, as big as the quill of a writing pen." He stated, somewhat surprisingly, that the young "were thirteen or fourteen in the same egg. . . . Seventy four were contain'd in six eggs." This statement is, however, to be explained by the fact that *E. subflavus* is ovoviviparous, and that Sloane misinterpreted what he saw.

Finally, Sloane (1725: 346) recorded that one of these snakes was tamed for him "by an Indian, whom it would follow as a dog would his master."

15. "Serpens major nigricans"; "The black Snake" (Sloane, 1725: 336).

Alsophis ater (Gosse), melanistic phase. Barbour (1937: 157), Grant (1940: 157), Lynn and Grant (1940: 122).

Leimadophis ater (Gosse). Barbour (1910: 300; 1914: 338).
Natrix atra Gosse (1851: 228).

This species is stated by Barbour (1937) to be "very rare indeed," having "suffered fearfully from the ravages of the mongoose." Grant (1940) stated that it has "probably been exterminated by the mongoose." However, Lynn and Grant (1940), while admitting that this snake is very rare, "would hesitate to pronounce it extinct," although they "did not meet anyone who had seen a live specimen in years."

Boulenger (1894) described the melanistic phase (*Dromicus ater*, var. A) as "uniform black or blackish olive; chin sometimes yellowish."

16. "Serpens major cinereus" (Sloane, 1725: 336).

Alsophis ater (Gosse), light phase. Grey Snake. *Ibid.*

Leimadophis ater (Gosse). *Ibid.*
Natrix capistrata Gosse (1851: 371).

Sloane recorded "a sort likewise of a light grey colour." Boulenger (1894) described this color phase (*Dromicus ater*, var. B) as "pale olive with small brown or black spots, a dark temporal streak, and usually a dark streak on the suture between the parietals."

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Literature Cited

Ahrenfeldt, R. H. 1953. Two British anatomical studies on American reptiles (1650–1750) – I.–Hans Sloane: comparative anatomy of the American crocodile. *Herpetologica, 9: 79–86.*

BARBOUR, T. 1910. Notes on the herpetology of Jamaica. *Bull. Mus. Comp. Zool., Harvard Univ., 52: 273–301.*
——— 1914. A contribution to the zoögeography of the West Indies. *Mem. Mus. Comp. Zool., Harvard Univ., 44: 209–359.*
——— 1934. Observations on Antillean tortoises and terrapins. COPEIA *(3): 111–3.*
——— 1937. Third list of Antillean reptiles and amphibians. *Bull. Mus. Comp. Zool., Harvard Univ., 82: 77–166.*
BOULENGER, G. A. 1885. Catalogue of the lizards in the British Museum. *London, 2: 290.*
——— 1889. Catalogue of the chelonians, rhynchocephalians, and crocodiles in the British Museum. *London: 157.*
——— 1894. Catalogue of the snakes in the British Museum. *London, 2: 121.*
BROWNE, P. 1789. The civil and natural history of Jamaica. *London, 2nd ed.: 466.*
CATESBY, M. 1743. The natural history of Carolina, Florida and the Bahama Islands. *London, 2: 38–40, pl. 38–40.*
DAUDIN, F. M. 1802. Histoire naturelle . . . des Reptiles. *Paris, 4: 287, pl. 55.*
DUMÉRIL, A. M. C., AND G. BIBRON. 1835. Erpétologie Générale. *Paris, 2: 89, 99.*
——— 1839. *Ibid. 5: 107, 590, 639.*
DUTERTRE, J. B. 1667. Histoire Generale des Antilles habitées par les François. *Paris, 2: 227–30.*
GOSSE, P. H. 1851. A naturalist's sojourn in Jamaica. *London.*
GRANT, C. 1940. Notes on the reptiles and amphibians of Jamaica. *In:* Jamaica To-day (ed. P. M. Sherlock). *London, 2nd ed.: 151–7.*
GRANT, C., AND C. R. DE SOLA 1934. Antillean tortoises and terrapins. COPEIA (2): *73–9.*
LABAT, J. B. 1722. Nouveau Voyage aux Isles de l'Amerique. *Paris, 1: 304–8.*
LEWIS, C. B. 1949. Glimpses of Jamaican natural history. *Kingston, Jamaica, 2nd ed., p. 28.*
LINNÉ, C. VON. 1758. Systema Naturae. *Holmiae, ed. 10, 1: 197.*
——— 1766. Systema Naturae. *Holmiae, ed. 12, 1: 350–1.*
LYNN, W. G., AND C. GRANT. 1940. The herpetology of Jamaica. *Bull. Inst. Jamaica, Sci. Ser., No. 1.*
MERTENS, R. 1934. Die Insel-Reptilien, ihre Ausbreitung, Variation und Artbildung. *Zoologica, 32: Lief. 6, Hft. 84, 1–209.*
RAY, J. 1693. Synopsis Methodica Animalium Quadrupedum et Serpentini Generis. *London: 254–8.*
ROCHEFORT, C. DE. 1681. Histoire naturelle et morale des Iles Antilles de l'Amerique. *Rotterdam, 3rd ed., 245–9.*
SLOANE, H. 1707. A voyage to the Islands Madera, Barbadoes, Nieves, St. Christophers, and Jamaica; with the natural history . . . of the last of those islands. *London, 1: xvii–xviii, xx, lxiv, lxxii, lxxxviii.*
——— 1725. *Ibid. 2: 331–6, 346–7, 395, pl. 273–4.*

BINSTED PLACE, NEAR ALTON, HAMPSHIRE, ENGLAND.

Habits of the Lizard *Liolaemus multiformis multiformis* at High Altitudes in Southern Peru

OLIVER P. PEARSON

THE only common reptile in the high mountains of southern Peru is an iguanid lizard, *Liolaemus multiformis mutiformis*. Large numbers of them live even above 15,000 feet where the climate is so severe at all seasons that one would expect a cold-blooded, terrestrial vertebrate to survive only with difficulty. The manner in which lizards do survive at high altitudes in the Departments of Arequipa, Moquegua, and western Puno is described below.

CLIMATE

Temperature and relative humidity throughout a typical autumn day may be illustrated by the records for April 18, 1952 (Fig. 1). Wide temperature variation between day and night is characteristic of mountain and desert climates, and in Peru is reproduced day after day throughout the year. In the autumn and winter months ahead, during which the lizards will copulate and become gravid, the days will be sunny and of about the same temperature as the one represented in the graph; the nights will be clear and much colder. In the summer months that have just passed, the days have been less sunny, the afternoons and evenings frequently snowy, and night temperatures slightly warmer than in the example illustrated but nevertheless almost always below freezing. A typical wet-season (summer) day begins sunny and clear, although the ground is frequently covered with snow. By 10 or 11 o'clock the intense sunshine has melted all the snow, but shortly afterwards clouds gather, and, in the

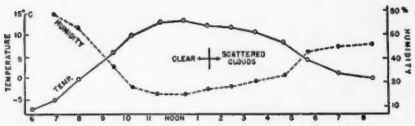


Fig. 1. Temperature and relative humidity record taken in the shade on a desert inhabited by many *Liolaemus*. April 18, 1952; 5 km. E. Lago Suche, 14,600 ft., Department of Moquegua, Peru.

Thermometer and Serdex diaphragm hygrometer situated one foot above the ground.

afternoon of many, if not most, days, hail or snow again falls and remains until the following morning. Further discussion of the climate and vegetation may be found in Bowman (1916), Weberbauer (1945), and Pearson (1951). The constant concern of every lizard is to make best use of the available insolation, for in the absence of sun productive activity is not long possible.

General Habits

When first encountered *Liolaemus m. multiformis* reminds one of *Sceloporus occidentalis* (Plate I). Forty-six sexually adult males (testes 6 mm. or longer) from high altitude in southern Peru measure between 73 and 103 mm. snout–vent, mean 87.0; 35 sexually adult females (ova 4 mm. or longer, or with corpora lutea) measure between 69 and 98 mm. (mean, 80.6). Young males and almost all females have a dorsal pattern (Plate I), and males tend to have brighter ventral colors than females, but, as the species name implies, there is surprising variation in both color and pattern.

Liolaemus is found in open country of sparse vegetation such as pampas of dwarf grass and tiny forbs, plains and slopes of scattered bunch grass and tola shrubs, and deserts of *Nototriche* where for many acres no plant projects above the surface of the ground. *Liolaemus* burrows are usually under stones and boulders or under the roots of tola shrubs (*Lepidophyllum*, *Baccharis*, *Senecio*). In regions where *Ctenomys*, a burrowing rodent, occurs, the lizards use its tunnels. *Liolaemus* can, however, excavate its own burrows. It is the most abundant vertebrate in many regions as high as 15,300 ft., and I have taken specimens as high as 15,800 ft. on Volcan Tutupaca. Schmidt (1945) records one from 16,000 ft.

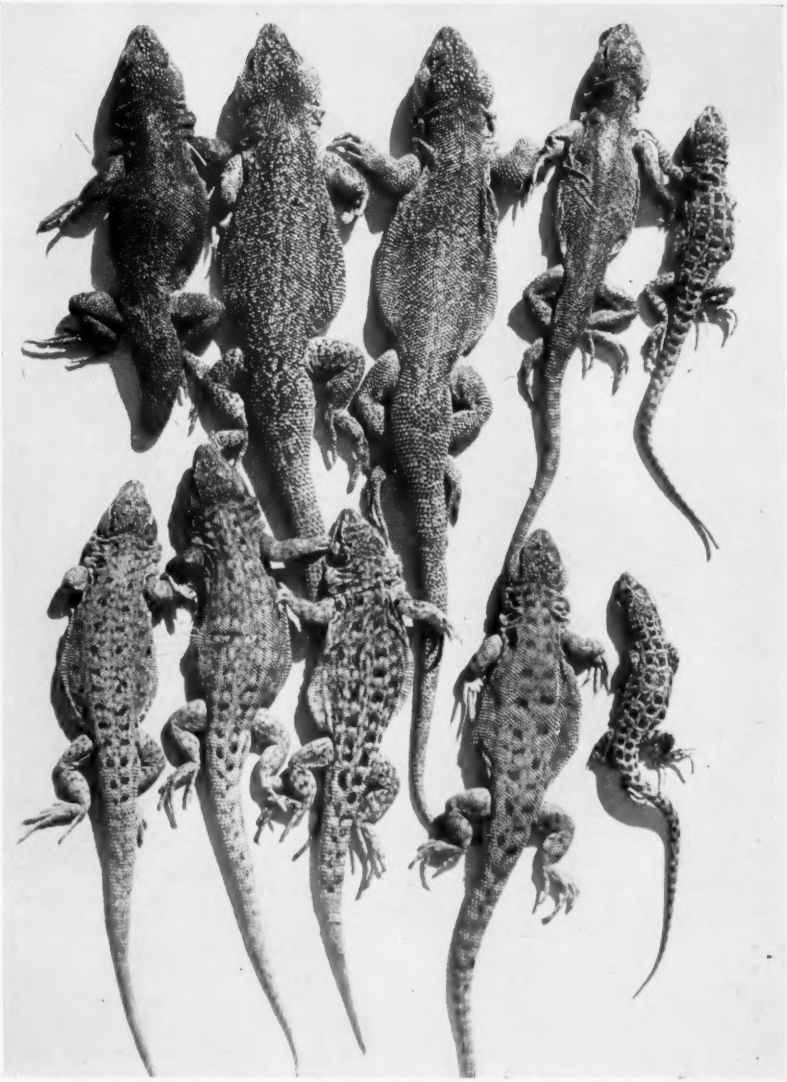
Liolaemus eats both plants and insects. I have seen the same individual vigorously tearing off and swallowing the leaves and blossoms of a *Nototriche* and a few minutes later chasing flies. Ability to eat plant material enables the lizard to feed under unfavorable climatic conditions when animal food might be unobtainable. The animal foods available are primarily flies, small butterflies, beetles and spiders.

Important enemies are foxes (*Dusicyon culpaeus*) and Andean caracaras (*Phalcoboenus megalopterus*). Skunks and sparrow hawks probably catch many also.

Regulation of Body Temperature

Much recent work (see especially Bogert' 1949) has pointed out the ability of ectothermic animals to control their body temperature by appropriate behavior. *Liolaemus* is remarkably adept at overcoming the temperature handicaps imposed by the high altitudes at which it lives. The rapid warming of *Liolaemus* in the morning when it emerges from its burrow depends upon the intense insolation found at these high altitudes and upon certain adaptations and habits of the lizards. First, the color of a cold *Liolaemus* is darker than that of a warm one. This presumably facilitates absorption of heat from sunshine. Second, when the lizards emerge from their burrows in the morning, they orient themselves head upwards on an inclined surface with the back toward the sun. In this position the sun's rays fall as fully as possible upon the back surface of the lizard. Third, the lizards seek a substrate that insulates them from the cold ground. Mats of dead bunch grass are favorite sunning spots, and such a mat, if favorably oriented with respect to the early morning rays, will be occupied every morning by the same lizard, or in succession by several lizards. Later in the day they bask on stones or on the ground.

Of basic importance to survival at high altitudes is the ability of *Liolaemus* to move in a coordinated fashion when its body temperature is so low that most species of lizards would be immobilized. For example, on April 18 a large male with a cloacal temperature of 35°C. was tethered at 14,600 ft. in the shade of a boulder at 10:05 AM. The air temperature in the shade one foot above the ground was 11°. At 10:32 AM his cloacal temperature had dropped to 12½°. He was sluggish but could *run* slowly. Another



Liolaemus m. multiformis from southern Peru. Top row, males; bottom row, females.

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male tethered in the shade at the same locality had the following record:

Time (PM)	Shade temp.	Rectal temp.	Remarks
4:45	8°	7½°	Can walk slowly, right himself, bite hard and long.
5:40	3½°	4°	Can walk and right slowly.
7:00	1½°	1½°	Can walk and right very slowly, hiss.

This ability to move when cold must enable them to reach underground shelter sometimes when, as a result of misfortune or behavioral blunders, they find themselves far from home in the afternoon with snow or numbing temperatures only minutes away.

When they emerge in the morning, their body temperature is probably that of their underground retreats, about 4° to 10°C., yet within minutes they have warmed to above 20°. I have captured one as cold as 13°, but others have warmed so quickly that I have not encountered them during the brief interval that their temperature was still close to that of their burrow. I have caught several above ground before 7:30 AM when the air temperature was still below freezing. One large male taken at 14,600 ft. at 6:55 AM on April 22 had a cloacal temperature of 19°. Air temperature in the shade close to the ground a few inches from the lizard was −5°. Temperature of the substrate, taken by sliding the bulb of a Schultheis quick-registering thermometer just under the sandy surface, was 5°. Another large male captured on April 19 at 7:20 AM, when the shade temperature was −4½°, was slightly sluggish, with a cloacal temperature of 14½°. The sandy substrate was 7°. A third example, a small lizard, was shot at 8:00 AM on April 18 when the shade temperature was 0°. Its cloacal temperature was 31°. By absorbing heat from the sun and substratum, this "cold-blooded" lizard was maintaining between its body and the air a temperature difference of 31°.

Captive lizards tethered out in the sun were able to warm themselves nearly one degree per minute, and the small lizards became warmed slightly faster than the large ones (Tables I and II).

Strelnikov (1944) reported that, at 13,100 ft. on a mountain in the Caucasus, the body temperature of a *Lacerta agilis* was at times as much as 29.2° above the temperature of the surrounding air. Bogert (1949) considered this report to be open to some doubt, but in view of the measurements recorded above, Strelnikov's figure is undoubtedly correct.

Since lizards tethered in the sun for several hours (Tables I and II) did not succumb, overheating does not seem to be a danger in this climate. The highest temperature recorded among wild lizards shot was 37°, but almost all were below 35°. My associate, Dr. Robert Stebbins, informs me that these temperatures are similar to those of *Sceloporus graciosus* and *S. occidentalis* collected in California.

Reproduction and Growth

Liolaemus m. multiformis is viviparous and gives birth from September to December. The

Table I

Cloacal Temperatures of Three Lizards Tethered on Gravel in Sunshine at 7:40 AM, at 15,200 ft., April 18, 1952

Measurements, given with sex, are snout-vent, in mm.

Time	Temperature, C°			
	Air, in shade	Cloacal		
		♂, 54	♀, 70	♂, 93
7:40 AM	−2	1	1	1
8:15 AM	−½	31	27	19
8:35 AM	0	28	31	26½
9:20 AM	6½	28	29½	31
12:20 PM	10½	34	33	..

Table II

Cloacal Temperatures of Two Lizards Tethered on Sand in Sunshine at 7:12 AM, at 12,900 ft., April 29, 1952

Measurements, given with sex, are snout-vent, in mm.

Time (AM)	Temperature, C°		
	Air, in shade	Cloacal	
		♂, 108	♀, 48
7:12	−2	2½	4
7:22	−½	10½	16½
7:32	−1	18½	20
7:42	−½	22½	24½
7:55	½	30½	24
8:17	1½	33	29
8:46	4½	35½	33
11:00	13	37	33

earliest date that we saw young was November 4, but the Chicago Natural History Museum contains specimens of young collected as early as September 11. On December 25 we captured a large female under a stone in association with four young that had an average snout-to-vent length of 33 mm. These young were probably several weeks old, for at the time of birth the young measure about 28 mm. I have seen fetuses as large as 29 mm. in a female captured September 21, and free-living young as small as 28 mm. taken on September 16. A 24-mm. individual captured November 11 may be abnormally small. By April, the season when adults copulate, the young have grown to about 50 mm., but their ovarian follicles are not more than 1 mm. in diameter, obviously immature. At the age of one year the snout–vent length has not increased much beyond the April size (Fig. 2), and the follicles are still less than 1 mm. in diameter. Although more specimens are needed to determine with certainty the age of first breeding, it seems likely that the follicles of both yearlings (about 16 months old) and adults begin to enlarge in February or March and reach a size of 8 mm. or more before rupturing near the end of April or early in May. Lizards smaller than 65 mm. did not contain large follicles.

A female copulating on April 22 contained unruptured follicles 7 mm. in diameter. The earliest ovulated, gravid female was captured April 25. Ova developing in the oviducts are slightly elongate and vary between 10.5 and 14 mm. in length. From the end of April until the season of birth beginning in September, all females more than 70 mm. long were gravid. Gestation, therefore, is about 5 months, and may be as long as 7 months in some individuals. Another set of follicles begins to enlarge 3 to 6 months after parturition and is ready to rupture near the end of April. Consequently each mature female (more than 70 mm., snout-to-vent) is able to bear young every year. Variation in the duration of gestation and the resulting variation in period from parturition until ovulation probably depend upon temperature conditions encountered by individual lizards. Gestation must proceed slowly during hibernation, and consequently its duration must depend upon how long the individual female hibernates.

In summary: beginning early in March (Southern Hemisphere autumn) follicles enlarge for 2 months, then rupture; embryos develop in the oviducts for 5 to 7 months until parturition; then ovaries are quiescent for 3 to 6 months.

The number of embryos, or of follicles 4 mm. in diameter or larger, in 20 females varied from 1 to 10, with a mean of 5.8.

Males become readily distinguishable from females when they reach a snout–vent length of about 50 mm. At this size the pre-anal scales of young males become enlarged and pigmented. The testes are still small, 2 mm. or less long, and the dorsal body coloration is still patterned as in juveniles and females (Pl. I). The pre-anal scales are similar to the enlarged scales associated with femoral pores in various other lizards.

In general the males, as well as the females,

Fig. 2. Growth and reproductive behavior of females of *Liolaemus*

The sizes of the circles are proportional to the diameter of the largest ovarian follicles (0.5 to 8 mm. in diameter). Dotted line indicates probable growth rate of young born in December. Specimens listed at the end of October were caught within 5 weeks of this time, but more precise dating is not available. Young whose sex was not determined by dissection are all recorded as females in this figure and do not appear in Fig. 4.

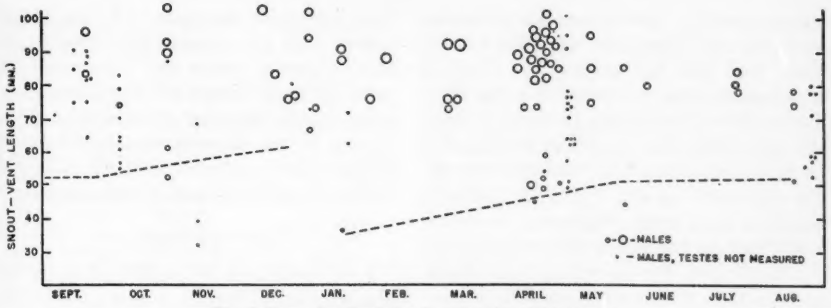


Fig. 3. Reproductive behavior of males of *Liolaemus*

Circles are proportional to size of testis (1 to 13 mm. long). Many young males whose sex was not determined by dissection are included in Fig. 2. Dotted line is taken from Fig. 2 and indicates probable growth rate of young born in December.

reach sexual maturity at a snout–vent length of about 70 mm. (Fig. 3). Only one male smaller than this had testes longer than 3 mm., and all males longer than 70 mm. had testes 4.5 mm. or larger, with two exceptions mentioned below. The testes of adults from December through May were large (6–13 mm.) and contained spermatozoa. The testes of the 74- and 78-mm. males taken August 16 were only 4 and 3 mm. long, respectively; these were the smallest testes found in any of the males over 70 mm. The 4-mm. testis was sectioned and found to contain a few meiotic figures but no spermatozoa. The ductus deferens was empty except for a few clumps of old, compacted spermatozoa. These facts suggest that the testes regress during the winter when the lizards are less active.

Several observations of territorial defense and courtship were made on a male and female living in sandy *Nototriche* desert at 14,600 ft. Each lived in a burrow under a large rock, the two rocks being 20 ft. apart. On April 19, 1952, the female emerged at 7:30 AM (shade temperature, −3°) and basked at the entrance to her burrow. The following activities were noted.

7:55—Female jumped at insect, then moved 2 ft. to another sunning place on dead grass.
7:56—Male arrived. Female ran off 5 ft., pumping up and down. (Pumping movements, displayed on occasions by both males and females, are accomplished by extending and flexing the legs, thereby raising and lowering the body jerkily in a motion reminiscent of "pushups".) Male then basked on the grass she had left.
8:02—Female ran off 15 ft., then returned to same place.
8:05—Male defecated, lifting hindquarters and arching tail.
8:12—Male moved to female's sunning place; she moved off 3 ft.
8:19—Two ground tyrants (*Muscisaxicola*) flew overhead; male and female lizard took shelter. Male reappeared in half a minute.
8:20—Female reappeared on a stone 1½ ft. from male, 5 ft. from her burrow.
8:35—Male approached her, but female ran off. Male usually stops on same spot that female has left, he not pumping.

On April 21, an adult male appeared next to the female's rock between 7:45 and 7:55 AM.

7:58—Male ran 5 ft. and basked on dead grass; occasional pumping movements.
8:01—Male ran 30 ft. toward me; more pushups.
8:10—Male ran to female's rock and climbed onto it.
8:28—Larger male appeared from down gulch and chased first male 20 ft., biting at his tail as they ran. Both disappeared.
8:40—A male walked up the gulch to one of the usual grassy sunning places 5 ft. from the female's burrow. (This male was the one that lived 20 ft. away, but I do not know whether he was the pursued or pursuer in the preceding chase.)
8:45—When I approached he walked on and around female's rock, but did not take shelter in her burrow.
10:20—Tethered a male 2 ft. from the female's rock.
10:28—Neighboring male from burrow 20 ft. away approached, pumping, and climbed onto female's rock.
10:30—Neighboring male attacked tethered male repeatedly.

At 8:00 o'clock on the morning of April 22 at the same place, I tethered a male outside of the female's burrow and another outside of the male's burrow. The resident male, however, instead of attacking either of them, approached me, then passed to my left. Just after he had passed me, another lizard dashed from behind me toward the male, and both disappeared behind a grass clump. I approached cautiously and discovered the male and a female "wrestling." After a few moments they settled

into a copulatory position on their sides, the male with a firm bite on the side of the female's neck. They held this position for about 15 minutes with no movement visible except slight respiratory motions. Finally the female wiggled and broke loose. They lay side by side, parallel, for about one minute, then the female ran off. The male stood up and after a few moments started to move away, whereupon the female dashed back, bit the male at the base of the tail, and ran off again. The male offered no resistance to this attack, then moved toward his burrow where he fought with the male that I had tethered there. The female contained six large ovarian follicles 7 mm. long, and spermatozoa were recovered from her oviducts. The testes of the male were 7 mm. long.

Hibernation

The scarcity of specimens obtained during the Southern Hemisphere winter reflects, in part, less collecting at that season and, in part, less above-ground activity by the lizards. I am indebted to Carl and Mary Koford of the Museum of Vertebrate Zoology for supplying most of the July and August specimens. They reported on August 9 that lizards were scarce above ground at that season and that all five lizards caught at noon on a sunny day, August 16, were under rocks. It will be interesting to discover whether this tendency for *Liolaemus* to remain inactive during the winter proves to be widespread in the region, for the winter days are about as warm and considerably sunnier than the summer days. Possibly the colder nights of winter cool the ground to a point where the lizards do not arouse themselves readily. A period of hibernation would account for the apparent cessation of growth of young lizards between April and November and for the relatively long gestation period.

Acknowledgements

I am grateful to Mr. Clifford Pope of the Chicago Natural History Museum and to Mr. Arthur Loveridge of the Museum of Comparative Zoology for the opportunity to examine lizards under their care.

Literature Cited

Bogert, C. M. 1949. Thermoregulation in reptiles, a factor in evolution. *Evolution 3: 195–211.*

Bowman, I. 1916. The Andes of southern Peru. *American Geog. Soc., New York: i–xi + 336 pp.*

Pearson, O. P. 1951 Mammals in the highlands of southern Peru. *Bull. Mus. Comp. Zool., Harvard Univ., 106: 117–74.*

Schmidt, K. P. 1945. A naturalist's glimpse of the Andes. *Sci. Monthly, 60: 335–46.*

Strelnikov, I. 1944. Importance of solar radiation in the ecology of high mountain reptiles. (Title of English summary.) *Zoologitsheskij Jour., 23: 250–7.*

Weberbauer, A. 1945. El mundo vegetal de los Andes Peruanos. *Ministerio de Agricultura, Lima: i–xix + 776 pp.*

Museum of Vertebrate Zoology, University of California, Berkeley, California.

Systematic Position of the Lake Trout, *Salvelinus namaycush*

Wm. Markham Morton and Robert Rush Miller

It has been recently proposed (Miller, 1950: 2) that *Cristivomer* again be regarded as a synonym of *Salvelinus*, and hence that the name of this distinctly American lake char[1], more commonly known as the lake trout, should revert to *Salvelinus namaycush* (Walbaum). This name was in use for some time prior to 1878 and was revived five years later (Jordan and Gilbert, 1883: 317). Following the recent proposal, the name *Salvelinus* [= *Cristivomer*] *namaycush* has been used by certain American ichthyologists (Hile, Eschmeyer, and Lunger, 1951: 77; Royce, 1951: 59; Lagler, 1952: 24; Legendre, 1952: 17; and Fry, 1953). The senior author has been collecting morphometric and meristic data on American salmonids (especially on chars) over the past decade and offers some of this material in support of the recent trend. Arguments for the generic recognition of

[1] Although the editors of Copeia have agreed to follow vernacular names adopted by the American Fisheries Society, one of us (W. M. M.) has prepared a treatise on the use of the word "char" which strongly supports the spelling "charr," preferred by him.

Cristivomer, lately proposed by Stokell (1951: 213–4), are discussed below.

Cristivomer Gill and Jordan, 1878

Cristivomer Gill and Jordan, in Jordan and Brayton (1878: 89). *Nomen nudum.*

Cristivomer Gill and Jordan, in Jordan (1878a: 356, 359). Listed and diagnosed. Two species (*namaycush* and *siscowet*) included; synonymy given; no type designated.

Cristivomer Gill and Jordan, in Jordan (1878b: 430). Additional synonymy.

Cristivomer Gill and Jordan 1878, in Jordan and Gilbert[2] (1883: 317–8). Diagnosed as subgenus of *Salvelinus* with type species (*Salmo namaycush* Walbaum) designated in footnote. *S. namaycush* described, synonymy given, and *siscowet* included as variety. Jordan (1878a) cited as original publication source, with *Cristivomer* credited to Gill and Jordan.

The proposal to synonymize *Cristivomer* with *Salvelinus* has been developing for a long time. Since 1880, ichthyologists who have mentioned this species have frequently expressed some degree of doubt as to its taxonomy. We cannot state the problem any more clearly or concisely than was done thirty-five years ago by William Converse Kendall (1919: 78–80) when he wrote:

> The generic name for the lake trout has undergone several changes since Walbaum in 1794 designated the species as *Salmo namaycush*. After the generic name *Salvelinus* for the char had been generally recognized, the lake trout being regarded as a char, was for some time, by American authorities at least, called *Salvelinus namaycush*.
>
> In 1878 Gill and Jordan bestowed upon it the generic name, *Cristivomer*. The character which distinguished the genus from *Salvelinus* was stated to be a raised crest behind the head of the vomer and free from its shaft, the crest being armed with teeth.
>
> In 1914 C. Tate Regan, of the British Museum, indicated that *Salvelinus fontinalis* possessed a backward extension of the head of the vomer, and in form and dentition was intermediate between a British char and the lake trout. For this reason he considered it advisable to give up the generic name *Cristivomer*. In the same year, in a paper which was in press at the time Regan's conclusion was published, the present writer [Kendall, 1914: 10–11] had stated a like conclusion based, however, on somewhat different characters of the vomers. He had found that some vomers of *Salvelinus stagnalis* from Labrador and *S. aureolus* from Floods Pond, Maine, could not be distinguished from the typical vomer of the lake trout, thus appearing intermediate between *S. fontinalis* and the lake trout. In the addenda to the same publication, however, attention was called to the discrepancy between Regan's and the present writer's observations, and the suggestion offered that neither char possessing lake trout-like vomers was intermediate between the lake trout and the other, but each independently derived from the ancestral form.
>
> Apparently both Regan and the present writer thought they had discovered something new concerning char vomers, but 26 years prior to our publications F. A. Smitt [1886] called attention to a similar situation, citing a specimen from Spitzbergen and one from Greenland which presented vomerine characters similar to *Cristivomer namaycush*. However, Smitt did not recognize even the genus *Salvelinus*. In fact his genus *Salmo* was the same as the subfamily Salmoninae of most recent ichthyologists.
>
> Inasmuch as the *Cristivomer* form of vomer is exceptional rather than the rule in the other chars, they may be regarded as vestigeal [sic]. However, the fact remains that the genera cannot always be distinguished by the character of the vomer.

In reversing his stand of 1914, Kendall in this paper held that differences in the morphometric proportions and direction of striae of the ethmoid bone justify the reestablishment of the genus *Cristivomer*. He presented proportional measurements from 3 or 4 ethmoids of each of four species of chars but of no other genera of the family.

A major factor in the retention of *Cristivomer* as a full genus has been that no comparative tabular or photographic evidence has been published that would permit one to compare *namaycush* objectively with other species of *Salvelinus*, especially with regard to the vomerine structures. It was the lack of such presentation in the many rehashed descriptions found in the huge general literature on salmonoids, and especially on chars, that inspired Morton to spend much time measuring, counting, and dissecting hundreds of specimens in order to obtain concrete comparative data on the better-known characters, or possibly to uncover some better ones. Results so far have impressed upon him chiefly that he has only scratched the surface of a very time-consuming problem. He has in preparation a revision of *Salvelinus*, and much of the data thus far obtained are utilized in the present account. In the section that follows, the best characters that have been used by others (or discovered in this study) to distinguish the lake trout from other chars are discussed in some detail.

The morphometric and meristic data included herein demonstrate that *S. alpinus* is intermediate between *S. namaycush* and the other American species considered. Such data further indicate that *S. alpinus* is a connecting link

[2] The date of publication of this volume is usually given as 1882, the year printed on the title page. However, as Jordan (1885: 789) pointed out, the volume was issued "about April 1, 1883." We are grateful to Carl L. Hubbs for this reference.

between typical lake-spawning chars, such as *namaycush*, and stream-spawning chars, such as *fontinalis*. Without access to more extensive series of the numerous Asiatic forms of *Salvelinus* (Berg, 1948: 269–95, figs. 156–171a), the comparisons cannot be considered exhaustive. The authors believe, however, that sufficient data are presented below to render a sound decision on the systematic status of the lake trout.

Differential Characters

Vomer.—The nature of the vomerine bone and of its dentition has been utilized as a major character for the generic recognition of *Cristivomer*. The character may be stated thus: vomer with a long, blade-like, raised crest extending backward from the head of the bone and free posteriorly from its shaft, the crest armed with a uniserial row of strong teeth. *Salvelinus* (*sensu stricto*), on the other hand, is generally credited with having the teeth confined to the head of the vomer (see Stokell, 1951: Figs. 2–3).

The vomers (Pls. I–II) of *Salvelinus fontinalis* (Mitchill), *S. malma* (Walbaum), *S. alpinus* (Linnaeus) and *S. namaycush* (Walbaum) were collected from various age groups to show the variations that may be encountered. It is noteworthy that the vomers vary considerably in shape, including, in other species, the "crested" form described as typical of *Cristivomer namaycush*. We recognize that the crested vomer tends to be better developed in *S. namaycush* than it is in other species of the genus *Salvelinus*, but the structure varies so much within the several species that its use for specific separation is much restricted (e. g., to distinguish *fontinalis* and *namaycush*).

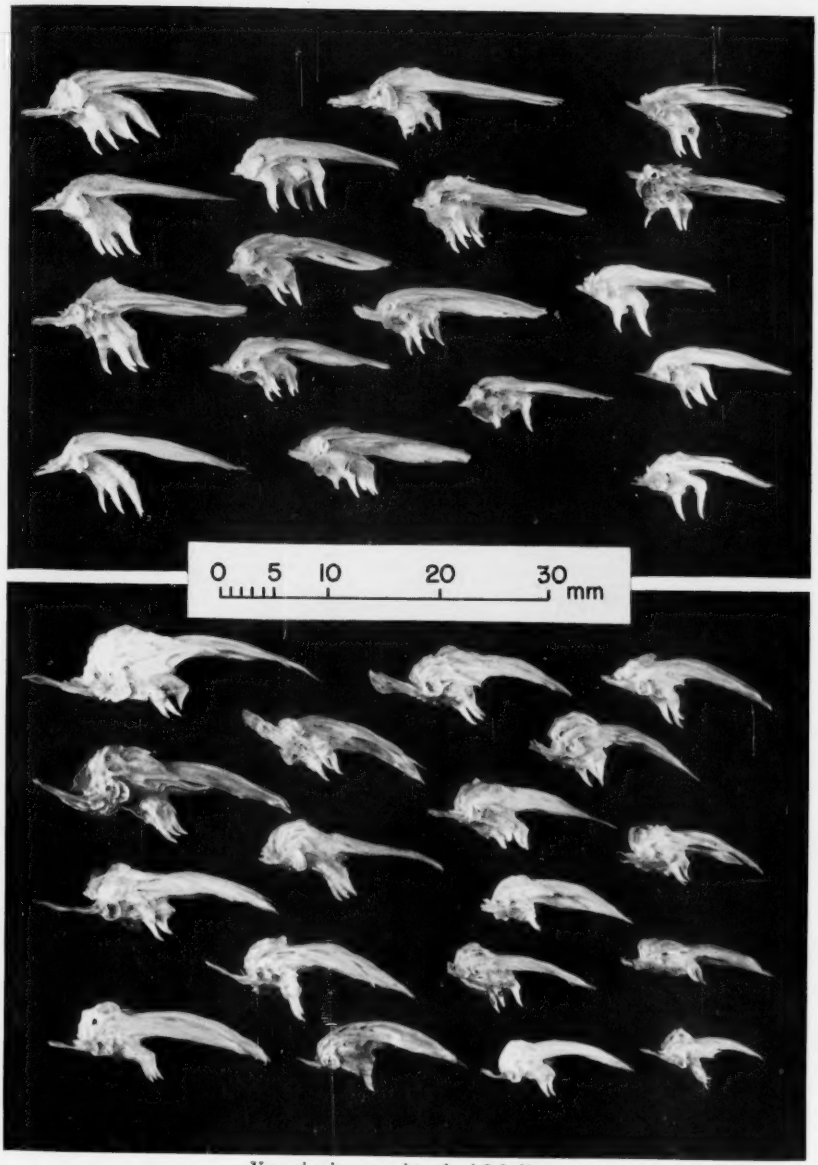
Table I

Number of Pyloric Caeca in American Chars (*Salvelinus*)

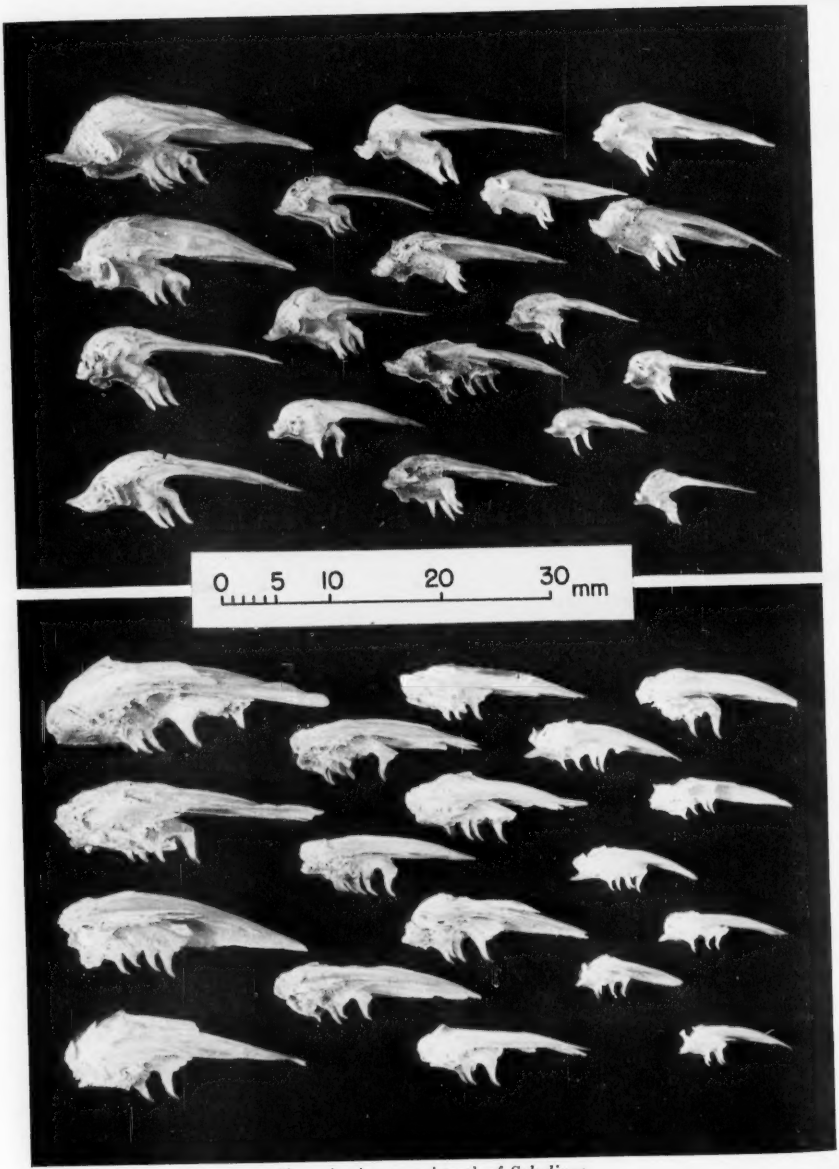
Number of caeca	Species			
	namaycush	*alpinus*	*fontinalis*	*malma*
16–20	..	..	..	1
21–25	..	..	6	33
26–30	..	1	12	50
31–35	..	5	13	24
36–40	..	11	11	6
41–45	..	12	4	
46–50	..	15	1	
51–55	..	12		
56–60	..	5		
61–65	..	1		
66–70	..			
71–75	..			
76–80	..			
81–85	..			
86–90	..			
91–95	2			
96–100	1			
101–105	2			
106–110	5			
111–115	4			
116–120	7			
121–125	8			
126–130	6			
131–135	3			
136–140	5			
141–145	3			
146–150	4			
151–155	..			
156–160	2			
161–165	1			
166–170	2			
Range.....	95–170	30–64	23–46	20–39
Specimens..	55	62	47	114
Mean.....	126.7	46.0	32.5	27.9

Pyloric Caeca.—The lake trout may be distinguished from other species of *Salvelinus* by its more numerous pyloric caeca, which number 95–170 in contrast to fewer than 65 in *alpinus*, *fontinalis* and *malma* (Table I). This feature was noted in Goode (1887: 462), who wrote: "'The lake trout', remarks Bean, '. . . seems to have no parallel in Europe and is well separated from American species by its peculiar vomer and its large number of pyloric caeca (about 150)'." This character is not often mentioned in the literature but we believe it is one of the most diagnostic for *namaycush*, for the lake trout seems to be approached in this character only by *alpinus*.

Basibranchial Teeth.—Jordan (1878a: 356) indicated that "a band of stout recurved teeth on the hyoid bone" is one of the stated characteristics of the genus *Cristivomer*. The teeth on the basibranchial bones (usually incorrectly called hyoid teeth) are numerous and multiserial in the lake trout and generally weaker and usually uniserial or biserial in the other species of *Salvelinus*. Partly on the basis of the nature of the basibranchial teeth, Regan (1914: 405) proposed to distinguish three groups of *Salvelinus*: the *alpinus* group, with uniserial dentition; the *fontinalis* group,



Vomerine bones and teeth of *Salvelinus*
Above: S. fontinalis from Kearneyville, West Virginia; January 15, 1942.
Below: S. malma from Karluk Lake, Alaska; summer, 1941.



Vomerine bones and teeth of *Salvelinus*

Above: S. alpinus from Karluk Lake, Alaska; summer, 1941.
Below: S. namaycush, juveniles, from Lake Michigan; 1942, 1946, and 1952.

without basibranchial teeth; and the *namaycush* group, with these teeth in a long patch.

Recently Stokell (1951: 213) has written that "The second character by which Regan [1914] proposed to separate his groups, namely, the hyoidal dentition, also fails in respect of *Salvelinus fontinalis*. It has been shown elsewhere (Stokell, 1940) that this species may or may not have teeth on the hyoid, and that when present these teeth are variable in number and degree of development. It is therefore impossible to separate *fontinalis* from other chars of the genus *Salvelinus*, and the proposed intermediate group must be abandoned. *Cristivomer*, however, has a multiserial arrangement of the hyoidal teeth and differs in this feature from all species of *Salvelinus* recorded." It was unfortunate that Stokell had not had the opportunity to examine specimens of *S. alpinus*. Our observations of the basibranchial teeth of chars, although not as extensive as desired, have shown that those of *alpinus* are intermediate between those of *malma* and of *namaycush*, and that the basibranchial teeth of *malma* bridge the gap between those of *fontinalis* and of *alpinus*. In more than a dozen American specimens of each of four species of *Salvelinus* examined by us independently, *namaycush* was invariably found to possess a multiserial arrangement of strong basibranchial teeth; *alpinus* had fewer rows of weaker teeth but definitely in two or more rows; in four of twenty specimens of *malma*, no basibranchial teeth could be found and in the remainder there were 1 to 14 usually rather weak teeth in a median or uniserial arrangement; and basibranchial teeth were lacking in all but two of forty-one specimens of *fontinalis*, each of which had a single tooth at the base of the second gill arch (Stokell, 1940, found as many as 1 to 7 teeth in this species). Similar variation in these teeth occurs in species of the genus *Salmo*.

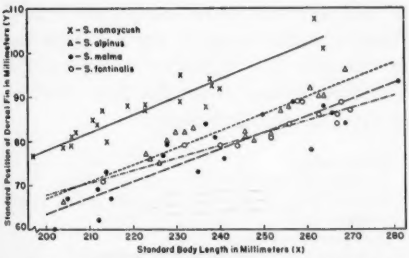

X – S. namaycush
Δ – S. alpinus
• – S. malma
o – S. fontinalis
Standard Position of Dorsal Fin in Millimeters (Y)
Standard Body Length in Millimeters (X)

Fig. 1. The relationship between position of the dorsal fin and standard body length in four species of *Salvelinus*.

The regression formulae are as follows: $y = -0.3 + .394x$ (*namaycush*); $y = -9.2 + .381x$ (*alpinus*); $y = -9.1 + .365x$ (*malma*); and $y = 11.1 + .284x$ (*fontinalis*).

Dorsal Fin Position and Forking of Caudal Fin.—From several morphometric characters that specifically characterize *Salvelinus namaycush*, we have selected the position of the dorsal fin and the forking of the caudal fin as the most diagnostic and as perhaps the most practical and available characters to supplement the very distinctive color pattern for quick diagnosis in the field or laboratory. For convenience of tabulation, data from similar size groups were selected for plotting these characters (Figs. 1 and 2). The standard body length is the projected lineal

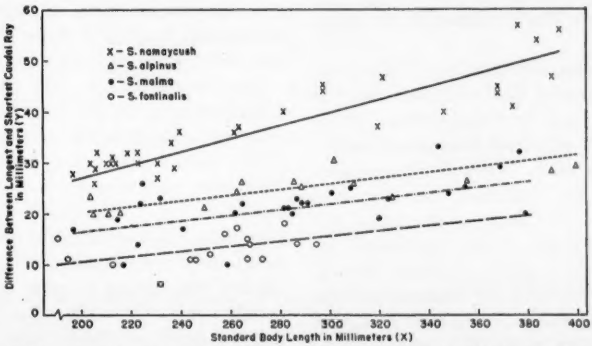

X – S. namaycush
Δ – S. alpinus
• – S. malma
o – S. fontinalis
Difference Between Longest and Shortest Caudal Ray in Millimeters (Y)
Standard Body Length in Millimeters (X)

Fig. 2. The relationship between forking of the caudal fin and standard body length in four species of *Salvelinus*.

The regression formulae are as follows: $y = 1.7 + .127x$ (*namaycush*); $y = 10.1 + .053x$ (*alpinus*); $y = 4.5 + .060x$ (*malma*); and $y = 1.2 + .048x$ (*fontinalis*).

distance from the occiput to the posterior end of the caudal peduncle (DeLacy and Morton, 1943: 85). The standard fin position is the projected lineal distance from the occiput to the origin of the dorsal fin. No overlap is indicated between *namaycush* and any of the three other definitely valid species of American chars. In these characters also *alpinus* is intermediate between *namaycush* on the one hand and *malma* and *fontinalis* on the other.

Scale Counts and Structure.—Stokell's observations (1951: 214) of limited material led him to conclude that "All chars of the genera *Salvelinus* and *Cristivomer* that have come under the writer's observation have considerably more cross-rows of scales on the body than scales in the lateral line. The lateral line scales are not composed of hard, transparent material as are those on other parts of the body, but are almost cutaneous in character. They carry no circuli and are flexibly connected. The arrangement differs greatly from that in *Salmo* and *Oncorhynchus*, in which the lateral line scales number approximately the same as the cross-rows and are similar to those on the remainder of the body except that each carries a mucus tube."

Our independent comparative studies of the scales of *Salvelinus* and *Salmo* fail to confirm any fundamental difference in either scale structure or counts. Scales studied were removed from the anterior portion of the lateral line, below the origin of the dorsal fin. The species studied included *Salvelinus alpinus*, *S. aureolus*[3], *S. fontinalis*, *S. malma*, and *S. namaycush*; *Salmo clarki*, *S. gairdneri*, *S. roosevelti*, *S. salar*, and *S. trutta*; and some of the American Pacific salmons of the genus *Oncorhynchus*.

The differences obtained by counting the scales in the lateral line and those above or below it have long been appreciated. This is why lateral-line scales have been seldom used to distinguish salmonids. Neave (1943) compared the methods and illustrated the differences between scale counts made on the lateral line and those along the oblique rows above the lateral line in three species of *Salmo*. Foerster and Pritchard (1935: 87–90) demonstrated the same thing for the five American species of *Oncorhynchus*. Our counts of *Salvelinus* and of specimens of *Salmo* not studied by Neave are summarized and combined with those of the above authors (Table II). Although very small scales have long been recognized as one of the general characteristics of the genus *Salvelinus*, a perusal of these tables demonstrates that similarly high counts occur in fine-scaled forms of *Salmo clarki* and in *Oncorhynchus gorbuscha*.

In scale structure, the American species of *Salvelinus* and *Salmo* form a rather evenly-graded series from the cutaneous, flexibly connected lateral-line scales of *Salvelinus namaycush* to the almost unmodified scales of *Salmo salar*. In contradistinction to Stokell's observations that the lateral-line scales of *Salvelinus* and *Cristivomer* lack circuli, we find weak to conspicuous circuli in the few specimens of the five species of *Salvelinus* studied by us (see also Cooper, 1951: Pls. I–II). The gradation in scale structure from a coarse-scaled type of *Salmo* into the fine-scaled forms of *Salvelinus* is indicated by the following approximate sequence, arranged from the least modified to the most specialized condition:

Salmo salar.
S. gairdneri kamloops, *S. g. whitehousei.*
S. clarki pleuriticus, *S. c. alpestris*, and *S. roosevelti.*
Salvelinus fontinalis.
S. alpinus, *S. aureolus*, and *S. malma.*
S. namaycush.

Those species listed together appear to be most nearly alike in details of squamation, with no broad gaps between the six groups. The scales of *Salvelinus fontinalis* bear similarities to both the extreme forms of *Salmo* and to the moderately specialized types of *Salvelinus*, thus bridging the gap between trouts and chars.

Mandibular Pores.—The presence of well developed pores on the mandible in the lake trout and other chars was mentioned by Stokell (1951: 214, as mucus pits), who thought this feature was almost exclusive to *Salvelinus* and *Cristivomer*. Our observations indicate that these pores are probably most conspicuous and numerous in *S. namaycush* (8 to 11, usually 9 or 10) and less obvious in other chars (4 to 10, usually 7 or 8 in *fontinalis* and *malma*), but that they are developed also in *Salmo clarki* and *S. gairdneri* and in at least *Oncorhynchus nerka*. Thus the number and arrangement of the pores,

[3] We follow current nomenclature. The status of this form is to be treated elsewhere.

TABLE II

A COMPARISON OF CERTAIN SCALE COUNTS IN AMERICAN SALMONIDS

For each taxa is given the range, followed by the number of specimens in parentheses, and, below, the average value of the character

Salvelinus	Number of scales (original data)	
	In lateral line*	In oblique rows
namaycush	121–130 (19) 125	175–228 (30) 196
alpinus	111–130 (12) 122	154–236 (28) 195
fontinalis	109–127 (28) 115	197–236 (25) 218
malma	120–131 (18) 126	186–254 (31) 231

Oncorhynchus	Foerster & Pritchard (1935)		Present study	
	Lateral line	Oblique rows	Lateral line*	Oblique rows
gorbuscha	148–198 (254) 172	169–231 (195) 199	147–180 (3) 166	194–226 (8) 213
kela	124–153 (155) 136	130–153 (135) 139	129–139 (6) 133	137–145 (5) 141
tshawytscha	130–153 (133) 140	133–153 (110) 143	130–138 (9) 134	138–158 (47) 149
kisutch	121–138 (127) 129	118–147 (124) 131	123–132 (10) 128	133–145 (9) 138
nerka	124–138 (145) 131	124–144 (173) 133	122–135 (10) 129	130–146 (16) 138

Salmo	Neave (1943)		Present study	
	Lateral line	Oblique rows	Lateral line	Oblique rows
salar	....	....	106–113 (11) 111	111–118 (11) 115
trulta	105–116 (25) 112	116–136 (25) 125	107–117 (11) 112	120–131 (11) 125
gairdneri†	119–131 (122) 124	123–143 (122) 132	....	125–149 (8) 137
gairdneri‡	114–124 (61) 120	115–130 (61) 122	119–125 (11) 122	146–164 (11) 154
kamloops	121–130 (25) 126	130–155 (25) 143	128	148 ....
clarki§	116–133 (50) 123	146–177 (50) 160	120–129 (6) 122	157–170 (6) 165
clarki¶	116–126 (30) 120	122–154 (30) 137	116–126 (13) 119	180–208 (13) 191

* Sensory pores; approximately the same as the number of scales.
† Anadromous. Our specimens are from Clackamas River, Oregon.
‡ Non-anadromous. Our specimens (UMMZ 130642) are from Rush Creek, Modoc Co., California.
§ The cutthroat trout in the present study are from coastal streams of Oregon and Washington.
¶ Specimens used in our study are *S. c. pleuriticus*, from the Colorado River Basin.

like that of the scales, forms a graded series between chars and trouts.

HYBRIDIZATION.—Although natural hybrids between the lake trout and other chars seem not to have been reported, it has long been known that *S. namaycush* can be crossed with *S. fontinalis* (Bean, 1889: 16–7). Recent studies by Stenton (1950, 1952), have shown that the

fertility of the parents and the development of the hybrids vary with the sex of the parents. When the milt of *fontinalis* was used to fertilize the eggs of *namaycush*, results appeared to be those normal to a natural species; in the reciprocal cross, however, high mortality and many deformed hybrids resulted. The F_1 hybrids seem to be fertile and the sex ratio to be approximately normal, but many F_2 hybrids were abnormal. There is no evidence at this time (October, 1953) that the hybrid will maintain itself under natural conditions. It is clear that there is only a partial genetic barrier to crossing between these species and that this barrier alone would presumably not be sufficient to prevent the normal development of many hybrids, at least to the F_2 generation. Differences in spawning-site requirements and in habits are probably largely responsible for the failure of lake trout and brook trout to hybridize in nature.

Discussion

Although *S. namaycush* is distinctly different in several ways from other species of the genus *Salvelinus*, it shares the two prime characters that separate the chars from other salmonid genera, especially *Salmo*. These are: (1) the presence of light spots against a darker background, rather than dark spots against a lighter background (as in *Salmo* and *Oncorhynchus*); and (2) the boat-shaped vomer, with teeth on the head only or on a crest that is extended posteriorly but which is always free from the shaft or connected with it only by a thin septum. In *Salmo* and *Oncorhynchus*, the vomer is long and relatively flat, with the teeth attached all along the shaft. (This difference was well illustrated by Hubbs and Lagler, 1952: 35.)

We agree with Kendall (1919) that "the lake trout represents a line of development distinct from the other chars." Three characters of *Salvelinus namaycush* that are not known to overlap with those of other species of *Salvelinus* are the coloration, the position of the dorsal fin, and the number of pyloric caeca. However, in most characters the Arctic char, *Salvelinus alpinus*, forms a connecting link between *S. namaycush* and the Pacific American and Eastern American brook species, *S. malma* and *S. fontinalis*. Although no overlap is indicated (Fig. 2) in forking of the caudal fin at the larger sizes between *namaycush* and the other three American species of *Salvelinus*, the drawings (Berg, *loc. cit.*) of some of the chars inhabiting eastern Asia show stages somewhat intermediate between the condition in *fontinalis* and *namaycush*. We are convinced that none of the characters of *S. namaycush*, either alone or in combination, is of sufficient importance or consistency to warrant generic separation of this species from the other chars.

As readily noted in the accompanying photographs (Pls. I–II), the major feature that has been used to distinguish *Cristivomer* generically from *Salvelinus*—vomer with an elevated, elongate crest armed with teeth—is not peculiar to *S. namaycush*, and hence this structure cannot be used for recognizing *Cristivomer* at the generic level.

The difference in number of pyloric caeca we regard to be of specific significance only. In many genera of fishes, the development of these structures differs markedly in different species as, for example, the variation from 45 to 195 caeca in *Oncorhynchus* (Clemens, 1935: K105).

In the six forms of *Salvelinus* studied, the basibranchial teeth grade from almost complete absence in *fontinalis* to the strong multiserial teeth of *namaycush*, with no marked break in the character that could be used to justify taxonomic isolation of the lake trout. As in *Salmo*, these teeth seem to be useful for specific rather than generic separation.

We do not attach significance at the generic level to the consistent difference in position of the dorsal fin of the lake trout, and we fail to find fundamental differences in scale structure or number that could be considered of generic importance.

The ability to hybridize with species of *Salvelinus* does not prove that the lake trout should be placed in the same genus, for many widely recognized genera of freshwater fishes are known to hybridize, at least occasionally (e.g., brown trout and brook trout). However, the degree of crossability and the fertility of the hybrids, considered along with the fundamental points of resemblance already discussed, lend support to the view that the relationships of the lake trout are more clearly expressed by classifying this species in the genus *Salvelinus*.

Unlike species, genera are not objective entities. Thus generic concepts vary greatly among systematists and reflect, in the main, the personal judgment of the investigator. A primary function of classification is to reveal natural affinities. We have independently concluded that the relationships of the lake trout are more clearly indicated by referring this species to *Salvelinus* than by isolating it as a monotypic genus. Those who wish to reflect the distinctive characters of the lake trout in its scientific name can readily do so by recourse to the subgenus, *Salvelinus* (*Cristivomer*) *namaycush*.

Summary

In conclusion we have indicated that: (1) A number of characters readily distinguish *S. namaycush* from all other members of the genus. The best of these, we believe, are color pattern, dorsal-fin position, the deeply forked caudal fin, and the large number of pyloric caeca. (2) The supposedly key generic character, a crested vomer, is found in other species of the genus *Salvelinus* and is not developed consistently in the lake trout. None of the other distinguishing characters of this species is regarded by us to be of generic value. (3) The species *namaycush* manifests very clearly all of the essential characters of *Salvelinus*, which we believe to be a recognizable genus. (4) Therefore we support the recent trend among American ichthyologists to suppress the genus *Cristivomer* as a synonym of *Salvelinus*.

Acknowledgments.—We are indebted to William L. Cristanelli of the Institute for Fisheries Research, Michigan Department of Conservation, for drafting the graphs, and to William L. Brudon, staff artist of the University of Michigan Museum of Zoology, for the carefully executed photographs.

Literature Cited

Bean, Tarleton H. 1889. Hybrids in Salmonidae. *Trans. Amer. Fish. Soc., 18: 12–20.*

Berg, Leo S. 1948. Freshwater fishes of the U.S.S.R. and neighboring countries. *Akad. Nauk, Moscow, 4th ed., vol. 1: 1–466, figs. 1–281 (in Russian).*

Clemens, W. A. 1935. The Pacific salmon in British Columbia waters. *Rept. Brit. Col. Comm. Fish., 1934: K103–5.*

Cooper, Edwin L. 1951. Validation of the use of scales of brook trout, *Salvelinus fontinalis*, for age determination. Copeia *(2): 141–8, pls. 1–2.*

DeLacy, Allan C., and Wm. Markham Morton. 1943. Taxonomy and habits of the charrs, *Salvelinus malma* and *Salvelinus alpinus*, of the Karluk drainage system. *Trans. Amer. Fish. Soc., 72 (1942): 79–91.*

Foerster, R. E., and A. L. Pritchard. 1935. A study of the variation in certain meristic characters in the genus *Oncorhynchus* in British Columbia. *Trans. Royal Soc. Canada, Sec. V: 85–95.*

Fry, F. E. J. 1953. The 1944 year class of lake trout in South Bay, Lake Huron. *Trans. Amer. Fish. Soc., 82 (1952): 178–92, figs. 1–2.*

Goode, G. Brown. 1887. American Fishes. Ed. 1. *Estes and Lauriat, Boston, 496 pp., illus.*

Hile, Ralph, Paul H. Eschmeyer, and George F. Lunger. 1951. Decline of the lake trout fishery in Lake Michigan. *U. S. Fish and Wildlife Serv. Fish. Bull. 60, vol. 52: 77–95.*

Hubbs, Carl L., and Karl F. Lagler. 1952. Fishes of the Great Lakes region. *Cranbrook Inst. Sci. Bull. 26: i–xi + 1–186, illus.*

Jordan, David Starr. 1878a. Manual of the vertebrates of the northern United States. . . Ed. 2. *Jansen, McClurg and Co., Chicago: 407 pp.*

——— 1878b. A catalogue of the fishes of the fresh waters of North America. *Bull. U. S. Geol. and Geog. Surv. (Hayden Surv.), 4 (2): 407–42.*

——— 1885. A catalogue of the fishes known to inhabit the waters of North America, north of the Tropic of Cancer, with notes on the species discovered in 1883 and 1884. *Rept. U. S. Comm. Fish and Fish., Pt. 13 (1885): 789–973.*

Jordan, David Starr, and Alembert W. Brayton. 1878. Contributions to North American ichthyology. III. A. On the distribution of the fishes of the Alleghany region of South Carolina, Georgia, and Tennessee, with descriptions of new or little known species. *U. S. Nat. Mus., Bull. 12: 1–95.*

Jordan, David Starr, and Charles H. Gilbert. 1883. Synopsis of the fishes of North America. *Ibid., Bull. 16 (1882): iv + 1018.*

Kendall, William Converse. 1914. The fishes of New England. The salmon family. Part 1. The trout or charrs. *Mem. Boston Soc. Nat. Hist., 8 (1): 1–103, pls. 1–7.*

——— 1919. Concerning the generic name, *Cristivomer* vs. *Salvelinus*, for the Great Lakes trout or namaycush. Copeia, *74: 78–81.*

Lagler, Karl F. 1952. Freshwater fishery biology. *Wm. C. Brown Co., Dubuque, Iowa, 360 pp., illus.*

Legendre, Vianney. 1952. Les poissons d'eau douce. Tome I. Clef des poissons de pêche sportive et commerciale de la Province de Québec. *Ministère Chasse et Pêcheries, Montreal, Québec: xiii + 84, 80 figs.*

Miller, Robert Rush. 1950. Notes on the cutthroat and rainbow trouts with description of a new species from the Gila River, New Mexico. *Occ. Pap. Mus. Zool. Univ. Mich., 529: 1–42, map 1, pl. 1.*

Neave, Ferris. 1943. Scale pattern and scale counting methods in relation to certain trout and other salmonids. *Trans. Royal Soc. Canada, sec. V: 79–91, figs. 1–2.*

Regan, C. Tate. 1914. The systematic arrangement of the fishes of the family Salmonidae. *Ann. Mag. Nat. Hist. ser. 8, vol. 13: 405–8, figs. 1–3.*

ROYCE, WILLIAM F. 1951. Breeding habits of lake trout in New York. *U. S. Fish and Wildlife Serv. Fish. Bull. 59, vol. 52: 59–76.*

SMITT, F. A. 1886. Kritisk förteckning öfver de i Riksmuseum befintliga Salmonider. *Kongl. Svensk. Vetenskaps-akademens Handl., 21 (8): 1–290.*

STENTON, J. E. 1950. Artificial hybridization of eastern brook trout and lake trout. *Canadian Fish Cult., No. 6: 20–2.*

——— 1952. Additional information on eastern brook trout × lake trout hybrids. *Ibid., No. 13: 1–7, fig. 1.*

STOKELL, G. 1940. The occurrence of hyoidal teeth in *Salvelinus fontinalis. Trans. Royal Soc. New Zealand, 70 (2): 161–3, pl. 15.*

——— 1951. The American lake char (*Cristivomer namaycush*). *Ibid., 79 (2): 213–7, pl. 26.*

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Observations on the Pygmy Whitefish, *Prosopium coulteri*, from Bull Lake, Montana

GEORGE F. WEISEL AND JOHN B. DILLON

As far as known, there are but two coregonid fishes native to Western Montana. One is the Rocky Mountain whitefish, *Prosopium williamsoni* (Girard), that is common in the larger lakes and rivers and has become an important sport fish. The other is the small pygmy or brownback whitefish, *Prosopium coulteri* (Eigenmann and Eigenmann), that is extremely rare. This species has been taken previously only once in Montana—from collections made in the mouths of Fish Creek and McDonald Creek, tributaries to Lake McDonald in Glacier National Park (Schultz, 1941). The few other recorded places where it has been caught are Kicking Horse River, British Columbia (Eigenmann and Eigenmann, 1892); Diamond Lake, Stevens County, Washington (Jordan and Snyder, 1909); Second Lake and Lake Aleknagik, Alaska (Kendall, 1917, 1921); and Chignik River, Alaska (Myers, 1932). Its recognized range is therefore from the headwaters of the Columbia River into Alaska, in waters tributary to the Pacific Ocean.

Inasmuch as the pygmy whitefish is taken so infrequently and so little is known of its habits, we believe it worth while to add some recently collected information to the sparse literature concerning the fish.

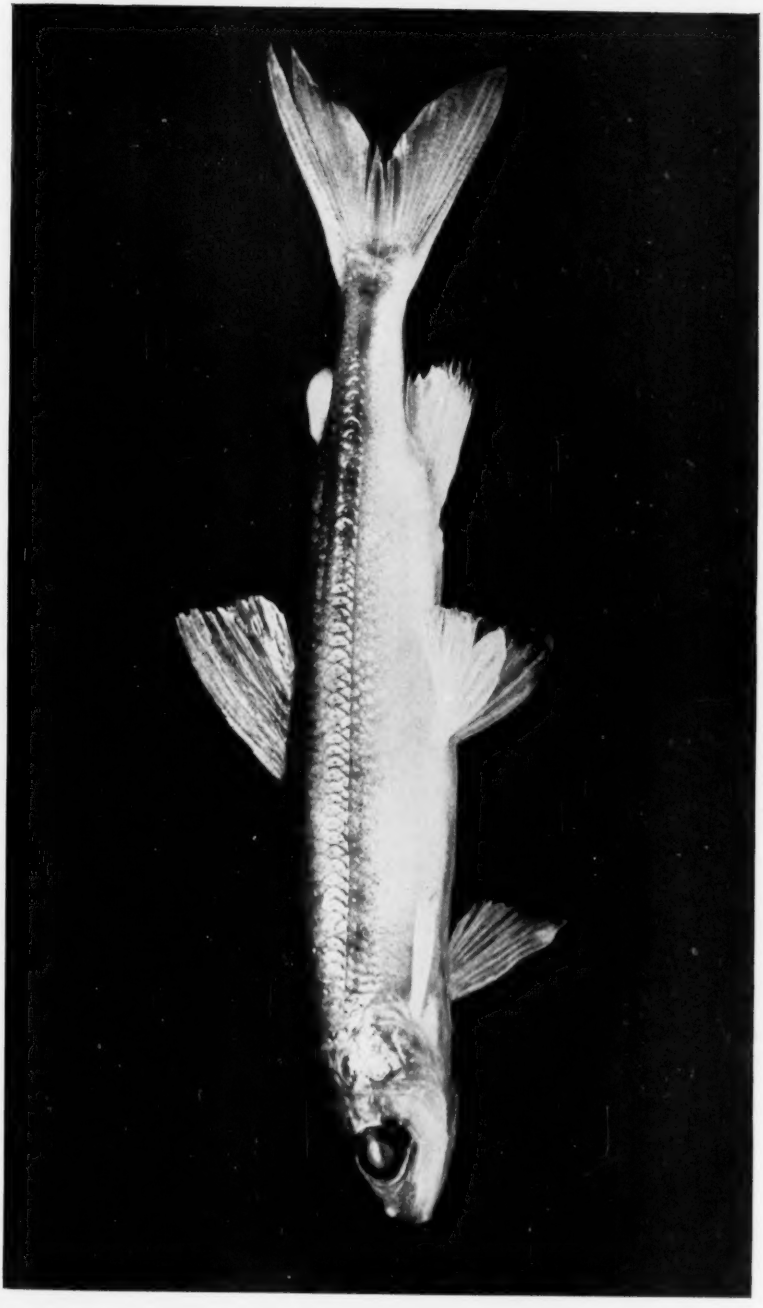
On December 26, 1952, the junior author observed large numbers of small whitefish in a sandy pool at the mouth of Ross Creek where it empties into Bull Lake. He successfully scooped up nine of these fish with a small dip net. They were *P. coulteri*. Eight days later he obtained six small *P. williamsoni* from a catch of 87 made by fishermen in the mouth of Stanley Creek at the opposite end of the lake. The fishermen believed they had seen a fish resembling the pygmy whitefish in Stanley Creek also, but were unable to catch any. However, Mr. Kenneth Hays returned to Ross Creek on January 12 and was able to catch fourteen more *P. coulteri* for us.

Bull Lake is in Lincoln County, Montana, and is tributary to the Kootenai River. It is about 9 miles long and averages about ½ mile in width. To our knowledge, no soundings have been made in the lake, but it is apparently quite deep for its size. Besides the two species of whitefish, other game fish that inhabit the lake include *Salvelinus malma* (Walbaum), *Salmo clarki* Richardson, and *Micropterus dolomieui* Lacépède.

DESCRIPTION AND COMPARISON WITH *Prosopium williamsoni*

The 23 specimens of the pygmy whitefish (Pl. I) were freshly preserved when descriptive notes and measurements were taken. The methods of counting and measuring followed the procedures recommended by Hubbs and Lagler (1947).

The back, top of head, and sides down to the lateral line are brown-olive in color, somewhat darker and browner than *P. williamsoni*. The cheeks are silver with a wash of gold; and the



Prosopium coulteri (Eigenmann and Eigenmann), a specimen 135 mm. in total length, from Bull Lake, Montana.

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In body
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Sex

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Male
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Male
Male
Male
Male
Male
Male
Male
Male
P. coulteri
Range. .
Average.
P. williams
Range. .
Average.

lower sides, throat, and belly are light silver. All but one specimen have well defined parr marks, which form irregular black blotches that vary from the size of the pupil to the size of the eye. There are 9 to 13 parr marks in a row along the lateral line and approximately the same number in a second row above them. There is a third row of 8 to 11 that follows the mid dorsal line, but these are less distinct.

In body proportions, *P. coulteri* is more slender, the eye is larger and the maxillary is longer than in *P. williamsoni* (Table I). The maxillary reaches to the anterior margin of the orbit or just beyond, whereas it ends somewhat short of the orbit in *P. williamsoni*. The head in profile is bullet-shaped and the anterior margin of the lower jaw is almost square, compared with the rather abruptly decurved head and narrow, rounded lower jaw of the other species.

In scale and fin ray counts, it is likewise strikingly different from the mountain whitefish (Table II). Although the gillrakers of the two species are similar in size and shape, they are less numerous in our specimens of *P. coulteri* than in *P. williamsoni*. However, Carl and Clemens (1948) recorded "about 26" gillrakers in specimens from British Columbia. It is notable that each meristic character is lower in *P. coulteri* than in *P. williamsoni* and that there is no overlap in these characters between the two species except for the number of pectoral rays.

The proportions and counts agree with those

TABLE I

SEX, AGE AND SOME PROPORTIONS OF *Prosopium coulteri* FROM BULL LAKE, MONTANA

The ranges and averages are compared with six specimens of *P. williamsoni* from the same locality

Sex	Age group	Standard length (mm.)	Depth in length	Head in length	Maxillary in head	Eye in head
Female	2	129	5.4	4.4	3.6	3.6
Female	2	120	4.8	4.3	3.3	3.5
Male	2	109	5.2	4.2	3.2	3.2
Male	2	108	5.1	4.2	3.5	3.3
Male	2	107	5.6	4.1	3.2	3.7
Male	2	106	5.3	4.2	3.3	3.1
Male	2	105	5.0	4.2	3.8	3.6
Male	2	104	5.4	4.1	3.6	3.6
Male	2	103	5.7	4.1	3.3	3.3
Male	2	102	5.1	4.3	3.4	3.4
Male	2	102	5.1	4.1	3.6	3.3
Male	2	99	5.8	4.0	3.5	3.5
Male	2?	97	5.4	4.1	3.3	3.6
Male	1	97	5.4	4.2	3.3	3.5
Male	1	96	5.3	4.3	3.2	3.2
Male	1	95	5.5	4.1	3.5	3.5
Male	1	94	5.9	4.3	3.7	3.7
Male	2?	93	5.6	4.0	3.5	3.5
Male	2?	91	5.4	4.0	3.2	3.2
Male	1	90	5.6	4.3	3.5	3.0
Male	1	88	5.2	3.9	3.8	3.2
Male	1	86	5.4	3.9	3.6	3.6
Male	1	81	5.4	4.0	3.4	3.4
P. coulteri						
Range		(81–129)	(4.8–5.9)	(3.9–4.4)	(3.2–4.1)	(3.0–3.7)
Average		100.0	5.3	4.1	3.4	3.4
P. williamsoni						
Range		(185–193)	(4.3–5.0)	(4.4–4.7)	(3.6–4.2)	(4.0–4.3)
Average		188.0	4.6	4.5	3.8	4.1

TABLE II

MERISTIC CHARACTERS OF *Prosopium coulteri* FROM BULL LAKE, MONTANA

The sequence of the individuals on which counts were made are the same as Table I. Most of the dorsal fins have two or more splints before the principal unbranched ray. These are not included in the count. The small scale just behind the anal opening is included in the count of transverse scales between the anal fin and the lateral line. Ranges and averages are compared with six specimens of *P. williamsoni* from the same locality

Fin rays				Scales		Gillrakers
Dorsal	Anal	Pelvic	Pectoral	Lat. line	D.-A.	
11	10	10	15	58	7/7	6 + 9
10	10	10	15	58	7/6	...
10	10	10	16	62	7/7	6 + 8
9	9	10	16	59	7/7	5 + 9
9	10	10	16	59	7/6	5 + 9
10	10	10	16	59	7/7	...
10	11	10	15	60	7/6	5 + 9
10	10	10	15	59	7/6	5 + 10
9	10	10	16	59	7/7	...
9	9	10	17	60	7/7	. .
10	10	10	16	62	7/7	...
10	10	10	15	58	7/7	...
10	10	10	16	63	8/7	...
10	10	10	15	63	7/7	...
10	10	10	10	59	7/6	...
10	10	9	15	63	7/7	...
11	11	10	16	60	7/7	...
9	10	10	15	59	7/7	...
10	10	10	14	60	7/7	...
9	10	10	15	58	6/6	...
9	10	10	15	61	7/7	...
10	9	10	15	61	7/7	...
9	10	10	15	54	7/7	...
*(9–11)	(9–11)	(9–10)	(10–17)	(54–63)	6-8/6-7	5-6 + 8-10
9.7	9.9	10.0	15.2	59.7		
**(12–13)	(12–13)	(11–12)	(17–18)	(74–77)	9-10/8-9	8-10 + 11-13
12.5	12.5	11.5	17.2	75.0		

* Ranges and averages for *P. coulteri*.
** Ranges and averages for *P. williamsoni*.

given by Eigenmann and Eigenmann (1892). On the whole they are also quite similar to fish from Alaska, although Kendall (1917, 1921) listed fewer transverse scales and gillrakers and about ten more scales in the lateral line.

Representing age groups by the number of annuli on the scales, our specimens of the pygmy whitefish are in age groups I and II. The annuli show clearly, there being only three individuals that we questioned. The fish in age group II range in standard length from 99 to 129 mm., whereas the mountain whitefish, all of this same age, range from 185 to 193 mm. in standard length. The largest *P. coulteri* reported is a female 174 mm. long from Lake Aleknagik, Alaska (Kendall, 1921).

SEXUAL MATURITY

Most collections of this species have apparently been taken during the spawning runs from deep lake waters into streams. Kendall (1921) stated that males and females caught in Alaska were in breeding condition in August, and that another collection from the territory was mature and ready to spawn on November 1. He also stated that spermaries and ovaries were well advanced by September in specimens from Kicking Horse River, British Columbia. In Lake McDonald, Schultz (1941) believed his fish caught in November were in spawning condition.

All of our fish are mature or have spawned. One female is spent and the other has the coelomic cavity packed with large eggs. Mr. Hays easily stripped eggs from one he took in January. Testes of most of the males are large and milky. The other males appear to have spawned shortly before caught. However, the maturity of fish, particularly males, cannot always be determined by gross examination. Therefore, smears of the testes were made and stained and examined under a microscope. They are full of mature sperm, and spermatogenesis is complete. In Bull Lake it is evident that this little whitefish matures early in life and spawns during late fall and early winter.

Tubercles are profuse on both males and females but are generally better developed on the males. They are located on the top of the head, on the paired fins, and on some of the scales above the lateral line. The female urogenital papilla is noticeably larger and more rounded than the papilla of male. In both sexes it is proportionately larger than in *P. williamsoni*.

The testes of the mountain whitefish from Bull Lake appear as though the fish had recently spawned. They are flaccid and the anterior ends are full of mature sperm. This species spawns from the middle of October to the middle of November in West Gallatin River, Montana (Brown, 1952) and from November to early December in Logan River, Utah (Sigler, 1951). No mature one- or two-year-old mountain whitefish were found in Utah, but those from Bull Lake have only two

annuli. The six examined from Bull Lake represent the smallest specimens taken, and undoubtedly the larger, older ones composed the majority of the spawners.

Discussion

It is well known that members of Coregonidae are a plastic group. A single species may vary considerably under different environmental conditions and separate races may exist in the same habitat. Many forms previously considered to be valid species have been reduced to synonomy (Monti, 1931; Dymond, 1943; Kennedy, 1953). One of the variations they exhibit is a form of dwarfism in which the fish are not only smaller but mature earlier and have a shorter life span (Klunzinger, 1900; Kennedy, 1943).

Prosopium coulteri is considerably smaller than *P. williamsoni* of the same age; has fewer scales, fin rays, and gillrakers; and may mature a year earlier. From existing data, it is not improbable that its life span never approaches the nine or ten years of *P. williamsoni*. It may be considered a dwarf whitefish, but not in the sense that it is just a variation within the species *P. williamsoni*. In the first place, it is markedly different from the mountain whitefish in the shape of its head, its meristic characters, and in many of its proportions. Furthermore, it cohabits with the mountain whitefish, yet no intergrades or hybrids between the two have been described; and although it is rarely caught, it covers a fair geographic range.

Literature Cited

Brown, C. J. D. 1952. Spawning habits and early development of the mountain whitefish, *Prosopium williamsoni*, in Montana. Copeia (*2*): *109–13, 1 fig.*

Carl, G. Clifford, and W. A. Clemens. 1948. The fresh-water fishes of British Columbia. *Brit. Col. Prov. Mus., Handbook No. 5: 1–132, 69 figs.*

Dymond, John R. 1943. The corgonine fishes of Northwestern Canada. *Trans. Roy. Canadian Inst., 24: 171–231.*

Eigenmann, Carl H., and Rosa S. Eigenmann. 1892. New fishes from Western Canada. *Amer. Nat., 26: 961.*

Hubbs, Carl L., and Karl F. Lagler. 1947. Fishes of the Great Lakes region. *Cranbrook Inst. Sci., Bull. 26: 186 pp., 251 figs., 25 pls.*

Jordan, David Starr, and John Otterbein Snyder. 1909. Description of a new whitefish (*Coregonus oregonius*) from McKenzie River, Oregon. *Proc. U. S. Nat. Mus., 36: 425–30.*

Kendall, William C. 1917. A second record for the Coulter's whitefish. Copeia, *45: 54–6.*

——— 1921. Further observations on Coulter's whitefish. Copeia, *90: 1–4.*

Kennedy, W. A. 1943. The whitefish, *Coregonus clupeaformis* (Mitchill), of Lake Opeongo, Algonquin Park, Ontario. *Univ. Toronto Stud. Biol. Serv., 51: 26–66, map, 1 pl.*

——— 1953. The morphometry of the coregonine fishes of the Great Bear Lake, N. W. T. *Jour. Fish. Res. Bd. Canada, 10: 51–61.*

Klunzinger, Carl Benjamin. 1900. Ueber Zwergrassen bei Fischen und bei Felchen insbesondere. *Jahresh. Ver. Vaterl. Naturk., Württemberg, 56: 519–32.*

Monti, Rena. 1931. Lampressa delle variagioni Presentate dai Coregoni italiani. *Arch. Zool. Ital., 15: 83–6, 13 figs.*

Myers, George S. 1932. A new whitefish, *Prosopium snyderi*, from Crescent Lake, Washington, Copeia (*2*): *62–4, 2 figs.*

Schultz, Leonard P. 1941. Fishes of Glacier National Park. *U. S. Dept. Int., Bull. 22: v + 42 pp., 26 figs.*

Sigler, William F. 1951. The life history and management of the mountain whitefish, *Prosopium williamsoni* (Girard) in Logan River, Utah. *Agri. Exp. Sta. Utah State Agri. Coll., Bull. 347: 1–21, frontis, 3 figs.*

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Oklahoma Lampreys: Their Characterization and Distribution[1]

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The recent acquisition of two fine series of lampreys, *Ichthyomyzon castaneus* Girard, and the paucity of lamprey literature pertaining to Oklahoma, prompts the presentation of this paper. For many years occasional specimens have been accumulating in the Museum of Zoology of the University of Oklahoma (UOMZ) and the Oklahoma Agricultural and Mechanical College (OAM). These specimens with others in the collections of Tulsa University (TU), University of Michigan Museum of Zoology (UMMZ), Cornell University (CU), and the

[1] Contribution No. 31 from the Oklahoma Fishery Research Laboratory and No. 204 from the Department of Zoology of the Oklahoma Agricultural and Mechanical College.

private collections of various persons, have been available for study.

The earliest Oklahoma lamprey record is that of Meek (1894) who took an ammocoete, presumedly *I. castaneus*, from Sallisaw Creek near McKey's Store (not Makey's Ferry as indicated by Hubbs and Trautman, 1937: 73, since there is no such place nor did Meek refer to a ferry). Sallisaw Creek is a small spring-fed stream which can be forded in numerous places, and certainly no ferry ever was needed. In June, 1950, by means of early maps and consultations with residents in the region, Moore located the site of Meek's collection at McKey's Store (Makey Store according to Meek, 1894, and Hubbs and Trautman, 1937: 76) on the old stage route between Fort Smith and Fort Gibson.

Hubbs and Trautman (1937) overlooked a small note by Moore (1933) who reported single adult specimens of *Ichthyomyzon concolor* (= *I. castaneus*) and *Reighardina unicolor* (misidentification since *R. unicolor* = *I. fossor*), later identified by Hubbs as *I. gagei*. The latter specimen was reviewed by Bailey (1947), who gave a more complete and more accurate characterization than did Moore.

Since Hubbs and Trautman (1937: 77) only presumed that the range of *I. castaneus* included Oklahoma, we assume that the specimen listed by them (p. 76) from Glover River was an ammocoete. The only Oklahoma specimens of *I. gagei* available to these workers were ammocoetes (p. 83). Therefore the only existing published records of adult lampreys from Oklahoma prior to 1950, are those of Moore (1933) and Bailey (same material, 1947). Hall (1953) called attention to an inadvertent error of Moore and Paden (1950) who credited Moore (1933) with reporting *I. unicolor* instead of *I. concolor*. Moore and Paden (1950) reported a specimen of *I. castaneus* from the Illinois River, and Hall (1953) listed an immature adult and an ammocoete of *I. castaneus* from the same stream. Hall and Latta (1952) recorded 12 immature adults of *castaneus* from the Poteau River.

In addition to the above published records, Hall has seen 2 immature adults of *castaneus* collected in Grand River below Fort Gibson Dam, on May 1, 1953, by Phillip Summers, a University of Oklahoma graduate student who (personal communication) said that numbers of lampreys were present there at the time. Through the courtesy of Dr. A. P. Blair, Moore has seen a large adult *castaneus* taken from the screen on the water intake line of the Public Service Company in West Tulsa, Oklahoma. This Arkansas River specimen had obviously been injured in early life, since the dorsal fin was abruptly divided. No counts or measurements were taken from the above specimens.

Ichthyomyzon castaneus Girard

Chestnut Lamprey

Material examined

Arkansas River System

Illinois River: Prater's Ford 3 mi. NE. of Gore, Sequoyah Co., 1 immature adult (OAM No. 1), W. D. Hargis, Bob Griffin, and Bud Martin, May 5, 1939; near Martin's Store E. of Moody in Secs. 13 and 24, T18N, R22E, Cherokee Co., 1 immature adult (OAM No. 8), Gordon E. Hall, Aug. 23, 1946 (reported by Moore and Paden 1950); mouth of Six-shooter Cr., below old Cookson, Cherokee Co., 2 immature adults (Fishery Research Lab., Norman), G. E. Hall and R. M. Jenkins, Feb. 17, 1953.

Poteau River: Stilling basin below Wister dam, LeFlore Co., 26 spawning adults (15 UOMZ No. 26160 and 11 OAM No. 4716), Lynn Hutchens, April 19, 1949; same locality, 12 immature adults (CU No. 20605), Gordon E. Hall, William C. Latta, and Lynn Hutchens, Sept. 7, 1951 (Reported by Hall and Latta, 1952).

Red River System

Mountain Fort River: State Game Refuge, McCurtain Co., 1 immature adult (OAM No. 4715), A. M. Surrell, May 2, 1950; at mouth of river, McCurtain Co., 2 ammocoetes (OAM No. 2834), G. A. Moore and Carl C. Rigney, Aug. 20, 1948.

Little River: E. of Cloudy Tower, Pushmataha Co., 1 immature adult (personal collection, Gordon E. Hall), Hall, G. A. Moore, and J. D. Reeves, March 23, 1951; mouth of Jack Cr., Pushmataha Co., 2 immature adults (OAM No. 4714), Hall, G. A. Moore, and J. D. Reeves, March 26, 1951.

DISTRIBUTION AND HABITAT.—This lamprey has been found principally in the medium-sized clear rivers and their chief tributaries in extreme eastern Oklahoma: Sallisaw and Spavinaw creeks, Grand, Illinois, and Poteau rivers in the Arkansas River System; Mountain Fork, Little, and Glover rivers in the Red River System (Fig. 1). On the southwestern edge of the known range for the species, Oklahoma specimens appear to be confined to about the same narrow distribution within the state presumed by Hubbs and Trautman (1937, Map,

p. 44). The only specimens of *castaneus* known to us from the Arkansas River are the type of *I. hirudo* Girard (1858: 382) from Fort Smith, Arkansas, and the one recently acquired by Dr. A. P. Blair from that stream at West Tulsa, Oklahoma.

CHARACTERISTICS AND COMPARISONS (Tables I and II).—Our methods of counting and measuring follow those used by Hubbs and Trautman (1937), who carefully described and evaluated each character necessary to distinguish between six species of *Ichthyomyzon*. Illustrations of the general tooth arrangement and other body structures of lampreys are shown by Vladykov (1949 and 1950).

Myomere and tooth counts and length measurements from 48 specimens of *I. castaneus*, including 42 from the Arkansas River System and 6 from the Red River System (myomere counts only from 2 ammocoetes), were summarized to secure the averages for this species in Oklahoma (Tables I and II). Ammocoetes were separated from adults, and a series of 26 spawning adults from the stilling basin below Wistar Dam were separated from another series of 12 immature adults taken from the same area two years later.

In the Oklahoma specimens there is very little variation in tooth counts of individuals or of a series from the same river in different years, from river to river within the same system, or from the Arkansas to the Red River System (Table I). Total length and proportionate size of parts tend to vary with the age of the individuals. Averages of immature and mature adults from the Poteau River (Table II) showed that total length, length of tail, depth of body (especially in gravid females), and length over gill openings tended to increase with age, whereas lengths of eye, snout, and disk tended to decrease with age, which is in accordance with the findings of Hubbs and Trautman (1937: 79). Adults examined ranged from 119 to 284 mm. of total length, but the smallest mature adult was 219 mm. The total lengths of 17 mature males varied from 222 to 278 mm. (mean 246.3) and those of 11 mature females from 219 to 284 mm. (mean 256.0). The number of eggs in the largest ripe female was estimated gravimetrically at 42,000.

The average counts and measurements of the various characters of Oklahoma *castaneus* deviated very little from those given by Hubbs and Trautman (1937), and each was included within the range they gave for that character. Notable variations in Oklahoma specimens included both a lower and a higher number of supraoral cusps and bicuspid circumorals, although average counts in both studies were exactly the same (Table I).

In each of all their 85 specimens of *castaneus*, Hubbs and Trautman found either two or three supraoral cusps. This was generally true with Oklahoma specimens also, but of 26 mature adults collected from the Poteau River below Wistar Dam in April, 1949, two had only one supraoral cusp, and of 12 immature adults collected from the same area in September, 1951, one had four supraoral cusps. According to the above authors, only *unicuspis*, of the three parasitic species of *Ichthyomyzon*, has a range of from one to four supraoral cusps. However, the three specimens from the Poteau River with these seemingly abnormal counts of supraoral cusps were good *castaneus* in every other respect, including counts of seven to nine circumoral bicuspids.

Hubbs and Trautman likewise reported from

• ICHTHYOMYZON CASTANEUS

o ICHTHYOMYZON GAGEI

Fig. 1. Distribution of lampreys in Oklahoma. (Only the eastern half of the state is shown.)

TABLE I

A SUMMARY OF THE MYOMERE AND TOOTH COUNTS OF *Ichthyomyzon castaneus* FROM OKLAHOMA IN COMPARISON WITH DATA FROM HUBBS AND TRAUTMAN (1937: TABLE X)

For each character in each locality are given the range (upper figures) and average (lower figure). Number of specimens in parentheses after locality

Locality	Myomeres	Supraorals	Infraorals	Circum-orals	Anterior rows	Lateral rows	Biscupid circumorals
Arkansas River System							
Illinois River (4)	54–56 55.0	2–3 2.5	7–10 8.7	19–23 20.7	4–5 4.5	7–9 8.2	8–11 9.0
Poteau River							
Mature adults (26)	51–55 52.8	1–3 2.3	7–11 8.4	19–22 21.0	4–5 4.5	6–9 7.8	0–10 6.7
Immature adults (12)	52–54 53.2	2–4 2.5	7–10 8.6	19–23 21.0	4–5 4.7	7–9 8.1	3–9 5.8
Summary (42)	51–56 53.1	1–4 2.4	7–11 8.5	19–23 21.0	4–5 4.6	6–9 7.9	0–11 6.6
Red River System							
Mountain Fork							
Adult (1)	†	3	8	20	5	8–9 8.5	6
Ammocoetes (2)*	50–52 51.0	...	...	...	...	...	...
Little River (3)	53–54 53.6	2–3 2.3	8–10 9.0	22 ...	4–5 4.6	7–8 7.7	4–8 6.0
Summary (6)	50–54 52.6	2–3 2.5	8–10 8.7	20–22 21.5	4–5 4.7	7–9 7.9	4–8 6.0
Grand Summary (48)	50–56 53.0	1–4 2.4	7–11 8.5	19–23 21.0	4–5 4.6	6–9 7.9	0–11 6.5
Hubbs and Trautman (85)	49–56 52.6	2–3 2.4	6–11 8.3	17–25 20.8	3–5 4.6	6–11 8.5	1–10 6.5

† Not distinguishable.
* Assigned to *castaneus* on the basis of low myomere counts.

one to ten bicuspid circumorals in their *castaneus* specimens. A single immature adult collected from the Illinois River in 1946 (Moore and Paden, 1950) was found to have 11, and another of the 26 adults from the Poteau River collection, previously mentioned, had no bicuspid circumorals. Specimens of *castaneus* with all unicuspid circumorals are undoubtedly rare, but they may be more common than was previously realized, since Moore has recently examined another specimen with the same condition from Caddo Lake, Texas.

In addition to the myomere and tooth counts and length measurements (Tables I and II),

TABLE II

A SUMMARY OF THE MEASUREMENTS OF *Ichthyomyzon castaneus* FROM OKLAHOMA IN COMPARISON WITH THE DATA FROM HUBBS AND TRAUTMAN (1937: TABLE X)

Total length in mm. and other measurements in thousandths of total length. For each character in each locality are given the range (upper figures) and average (lower figure). Number of specimens in parentheses after locality

Locality	Total length	Tail length	Body depth	Eye length	Snout length	Disk length	Gill openings, length overall
Arkansas River System							
Illinois River (4)	197–231 215	252–282 270	74–78 76	11–12 12	84–103 94	65–81 74	95–102 99
Poteau River							
Mature adults (26)	219–284 252	253–314 285	72–104 86	7–13 11	73–91 82	56–73 65	100–120 108
Immature adults (12)	176–205 191	253–285 267	71–92 83	9–14 12	88–107 93	58–84 73	90–115 106
Summary	219–284* 231	252–314 278	71–104 84	7–14 11	73–107 86	56–84 68	90–120 107
Red River System							
Mountain Fork (1)	163	288	67	9	98	84	92
Little River (3)	119–154 139	256–277 267	67–74 70	16–17 17	94–108 103	63–90 79	92–98 95
Summary (4)	119–163 145	256–288 272	67–74 69	9–17 15	94–108 102	63–90 80	92–98 95
Grand Summary (46)	219–284* 224	252–314 277	67–104 83	7–17 11	73–108 87	56–90 69	90–120 106
Hubbs and Trautman (85)	200–310* 216	250–335 282	59–109 90	7–17 11	75–109 90	63–91 77	83–114 94

* Range is for breeders only; the average is of all adults.

Oklahoma *castaneus* are characterized by having transverse lingual laminae which are generally linear to slightly bilobed. Hubbs and Trautman (1937: 79) pointed out that this organ is rarely rather strongly bilobed in *castaneus*. An immature adult (197 mm.) from the Illinois River was the only specimen of 44 adults which possessed a distinctly bilobed lamina. In the remainder the lamina was linear in 16 and slightly bilobed in 27. The black sense organs which tend to become darker with age and the pale yellowish-olive fins with the belly slightly darker and grading to dark olive above in Oklahoma specimens is in agreement with the color descriptions by the above authors (p. 79).

ABUNDANCE, INFESTATION, AND ECONOMIC IMPORTANCE.—Recorded collections in Oklahoma to date, show *castaneus* to be more abundant in the Arkansas than in the Red River System, and far more specimens have been taken from the Poteau River than any other stream. Although the present records are no criterion of the actual abundance in any one stream or river system, they do indicate that the species is more abundant in Oklahoma than was previously realized.

The better methods of fish sampling (rotenone, electric shockers, nylon gillnets) employed in recent years may be in part responsible for the greater number of lampreys appearing in later collections. In addition, the construction of many multi-purpose dams in Oklahoma in the last 10 years has undoubtedly created better downstream habitat for the parasitic *castaneus*. With the reservoirs acting as silting basins the downstream areas are generally clearer than before, and, since the larger dams are usually barriers to upstream migration, fishes are often concentrated in the stilling basins immediately below the dams (Hall and Latta, 1952). The majority (38) of the specimens used in the present study came from the stilling basin below Wistar Dam in separate collections two years apart.

Since previous knowledge of the abundance of *castaneus* in Oklahoma has been limited, its parasitism of fishes has generally been considered unimportant. However, statements by fishermen who have caught fishes with lampreys attached are becoming more common. In the last three years such communications have come from Spavinaw Creek, Illinois River and its tributary Barren Fork, and Black Fork of the Poteau River in the Arkansas River System; and Mountain Fork and Jack Creek, tributaries to Little River in the Red River System. Fishes upon which we have found attached lampreys or visible scars include *Moxostoma aureolum*, *Moxostoma erythrurum*, *Moxostoma carinatum*, *Ictiobus bubalus*, *Cyprinus carpio*, *Lepomis cyanellus*, *Micropterus salmoides*, and *Micropterus dolomieui*.

It is doubtful whether this parasite is abundant enough in Oklahoma to warrant control and, if so, whether a satisfactory and economical means of controlling it is possible. Nevertheless, with the construction of more dams, the continued increase in number of fishermen, and the biological survey of other streams, many more records of *I. castaneus* can be expected.

Ichthyomyzon gagei Hubbs and Trautman

Southern Brook Lamprey

Material examined

Arkansas River System

Barren Fork Creek: Tributary of Illinois R., 10 mi. E. of Tahlequah, Cherokee Co., 1 adult (UMMZ No. 119976, data from Bailey, 1947; first reported by Moore, 1933), Jack Baker, April, 1931.

St. Louis Double Spring: Tributary of Grand (Neosho R.), NE. of Hulbert, Cherokee Co., 1 spawning adult (OAM No. 461), G. A. Moore, May 3, 1947.

Big Spring Creek: Tributary of Grand R., 5 mi. S. of Locust Grove, Mayes Co., 3 spawning adults (1 in OAM No. 4170 and 2 in TU), A. P. Blair, May 7, 1949; same locality, 1 ammocoete and 1 spawning adult (TU), A. P. Blair, April 22, 1950.

Spavinaw Creek: Tributary of Grand R., between Spavinaw and Upper Spavinaw lakes, Delaware Co., 2 spawning adults (personal collection Gerald Taylor), Samuel Jackson, April, 1952; Spavinaw L., 3 spawning adults (TU), A. P. Blair, May, 1952.

Poteau River: At bridge near Hodgen in Secs. 35 and 36, T5N, R25E, LeFlore Co., 1 ammocoete (OAM No. 1115), questionable identity, G. A. Moore, Aug. 24, 1947; Black Fork at Freeman's Hole near Zoe in Sec. 28, T4N, R26E, LeFlore Co., 2 ammocoetes (OAM No. 1027), questionable identity, Gordon E. Hall, Aug. 22, 1947; Black Fork in Sec. 6, T4N, R26E, LeFlore Co., 12 ammocoetes (OAM No. 1283), questionable identity, G. A. Moore, Aug. 25, 1947.

Red River System

Gates Creek: At Fort Towson, Choctow Co., 1 adult and 1 ammocoete (OAM No. 4688), M. B. Trautman, G. A. Moore and Milton Curd, May 26, 1950.

Kiamichi River: At Big Cedar, LeFlore Co., 1 ammocoete (TU), questionable identity, A. P. Blair, May 2, 1953.

Distribution and Habitat.—Hubbs and Trautman (1937: 80) collected 2 ammocoetes, which were doubtfully identified as *I. gagei*, in the Elk River, Delaware County, Oklahoma, on September 13, 1935, and, on the basis of these specimens, predicted the high probability that this species occurs in northeastern (typographical error "northwestern") Oklahoma. Oklahoma collection records to date indicate *I. gagei* has a distribution within the state similar to its parasitic counterpart, *I. castaneus*. However, *I. gagei* was found generally in the smaller streams, often the lesser tributaries of the same rivers from which *I. castaneus* has been collected. Ammocoetes were taken from slowly moving water or from backwater pools with soft mud banks; adults from gentle, trash-littered riffles connecting cut-off pools with the main streams.

Characteristics and Comparisons (Table III).—Counts and measurements from 12 adult *I. gagei*, including 11 from the Arkansas River System and 1 from the Red River System, are summarized (Table III) to secure the average characteristics of this species in

TABLE III

A SUMMARY OF THE CHARACTERS OF *Ichthyomyzon gagei* FROM OKLAHOMA IN COMPARISON WITH DATA FROM DENDY AND SCOTT (1953)†

The numbers of specimens are indicated in parentheses. Upper figures represent ranges and lower ones are averages. Proportional body measurements are expressed in thousandths of total lengths

Character	Arkansas River System		Red River System		Grand averages (12)	Dendy and Scott (100)
	Adults (11)	Ammocoetes (16)	Adults (1)	Ammocoetes (2)		
Myomeres in trunk	48–57 54.3	50–55* 52.6	58	53–55* 54	48–58 54.6	49–59 53.6
Supraoral cusps	1–3 2.5	...	2	...	1–3 2.5	2–5 2.7
Infraoral cusps	7–11 9.5	...	11	...	7–11 9.6	5–12 8.5
Teeth in circumoral row	20–24 21.4	...	21	...	20–24 21.4	19–30 22.1
Teeth in anterior row	4–6 4.7	...	4	...	4–6 4.6	2–4 3.6
Teeth in lateral rows	5–8 6.5	...	6–5	...	5–8 6.4	5–9 6.5
Bicuspid circumorals	3–10 7.2	...	8	...	3–10 7.3	0–10 5.5
Total length in mm.	115–160 137	49–151* 94	108	57–94* 75	108–160 133	80–159 113
Length of tail	258–374 291	214–271* 252	252	223–245* 234	252–374 288	240–339 291
Depth of body	55–94 79	57–70* 65	61	61–69* 65	55–94 77	55–109 81
Length of eye	11–16 13	...	13	...	11–16 13	6–17 12
Length of snout	49–80 62	...	55	...	49–80 61	40–79 63
Length of disk	40–54 47	...	37	...	37–54 46	25–74 47
Length over gill openings	99–116 105	...	104	...	99–116 105	85–124 105

† Averages of Dendy and Scott's material are weighted means compiled from histograms in their paper.
* Identification of ammocoetes somewhat doubtful; counts and measurements not included in grand averages.

Oklahoma. Myomere counts, total lengths, tail lengths, and body depths taken from 18 ammocoetes of questionable identity are not included in the grand averages. The ammocoetes were assigned to *gagei* on the basis of well developed gonads in the larger specimens.

In their meristic characters, Oklahoma *gagei* differ from Oklahoma *castaneus* in having a

significantly higher average number of myomeres, infraoral cusps, and bicuspid circumorals, and a lower average number of lateral teeth. Supraoral, circumoral, and anterior tooth counts are very similar. As indicated by Hubbs and Trautman for the species, the Oklahoma specimens of *gagei* have a smaller maximum size, a smaller disk, and a shorter snout than *castaneus*. Proportionate tail and eye lengths average slightly higher in *gagei*, but lengths over gill openings average about the same.

Adults examined were all mature and range from 108 to 160 mm. Dendy and Scott (1953), who had only one specimen from Oklahoma, gave the range as 80 to 159 mm. The average total length (134 mm.) of Oklahoma specimens substantiates a suggestion by Raney (1952) that the largest specimens of *gagei*, which is the largest of the nonparasitic *Ichthyomyzon*, may be from the western part of its known range, Oklahoma and Texas. In reporting lengths of *gagei* from Alabama, Raney (1952) also suggested that the female of this species attains a larger size than the male. The total lengths of 7 male *gagei* from Oklahoma range from 108 to 160 mm. (mean 129.6), and 3 females from 130 to 150 mm. (mean 138.0). (Dendy and Scott gave these ranges as 80 to 149 mm. for males and 100 to 159 mm. for females.) Thus, although the average total length of our female specimens is greater than that of our males, the largest specimen is a male. The number of eggs in one gravid female (150 mm. total length) was estimated gravimetrically at 1,300, which is within the range (1,000 to 3,264) recorded by Dendy and Scott.

Average myomere and tooth counts of Oklahoma *gagei* varied considerably from those reported by Hubbs and Trautman. The most striking difference is in the greater number of myomeres, 54.6 in the Oklahoma specimens as compared to 52.3 in theirs. The above authors characterized *gagei* as having 51 to 54 myomeres, but, of 30 adults and ammocoetes examined by us, 2 had fewer than 51 myomeres and 11 had more than 54. The variability for this character in *gagei* is now known to be from 48 to 58, in close agreement with Dendy and Scott, who recorded 49 to 59. Ranges for all tooth counts were likewise increased with the addition of the Oklahoma data to that listed by Hubbs and Trautman.

The largest specimen examined by Hubbs and Trautman was 126 millimeters total length. Of the 12 adults examined by us, 8 were larger than this and the largest was 160 millimeters. Average proportional body measurements were similar in both studies. The linear to slightly bilobed transverse lingual laminae and the weakly developed posterior teeth are apparently characteristic of *gagei* throughout its range. Oklahoma specimens were of an olive brown color with scattered melanophores on the light olive belly.

Oklahoma *I. gagei* (Table III) differ, perhaps significantly, from material studied by Dendy and Scott, from regions largely other than Oklahoma, in having more teeth in the anterior row and a larger size, as shown in total and tail lengths.

ABUNDANCE.—As with *I. castaneus*, the great majority (90 percent) of specimens of *I. gagei* from Oklahoma have come from the Arkansas River System, and the Poteau River in particular. Although no adults of *gagei* have been taken from the Poteau River, 16 ammocoetes from that stream or its tributaries are assigned to this species. Of the 12 adults, from which data were used to characterize *gagei* in Oklahoma, 5 were from Big Spring Creek and 4 from Spavinaw Creek, both of which are Grand River tributaries. This small nonparasitic lamprey is of little or no economic importance, but future collections will undoubtedly reveal its presence in many of the other small tributaries of eastern Oklahoma.

LITERATURE CITED

BAILEY, REEVE M. 1947. Records of the lamprey (*Ichthyomyzon gagei*) in Oklahoma and Texas. COPEIA (*2*): *146*.

DENDY, JACK S., AND DONALD C. SCOTT. 1953. Distribution, life history, and morphological variations of the southern brook lamprey, *Ichthyomyzon gagei*. *Ibid.*, (*3*): *152–62, figs. 1–3, pl. 1*.

GIRARD, CHARLES. 1858. Fishes. In: General report on the zoology of several pacific railroad routes. *U. S. Pac. R. R. Surv., 10 (4): 1–400, 21 pls.*

HALL, GORDON E. In press. Observations on the fishes of the Fort Gibson and Tenkiller Reservoir areas, 1952. *Proc. Okla. Acad. Sci., 33 (1952)*.

HALL, GORDON E., AND WILLIAM C. LATTA. 1952. Pre- and post-impoundment fish populations in the stilling basin below Wister Dam. *Ibid., 32 (1951): 1–6*.

HUBBS, CARL L., AND MILTON B. TRAUTMAN. 1937. A revision of the lamprey genus *Ichthyomyzon*. *Misc. Publ. Mus. Zool., Univ. Mich., 35: 1–109, pls. 1–2, figs. 1–5, map 1.*

MEEK, SETH E. 1894. Report of investigations respecting the fishes of Arkansas, conducted during 1891, 1892, and 1893, with a synopsis of previous explorations in the same state. *Bull. U. S. Fish. Comm., 14: 67–94.*

MOORE, GEORGE A. 1933. Two lampreys from Oklahoma. *Proc. Okla. Acad. Sci., 13 (1932): 11.*

MOORE, GEORGE A., AND JOHN M. PADEN. 1950. The fishes of the Illinois River in Oklahoma and Arkansas. *Amer. Midl. Nat., 44 (1): 76–95.*

RANEY, EDWARD C. 1952. A new lamprey, *Ichthyomyzon hubbsi*, from the Upper Tennessee River System. COPEIA *(2): 93–9, pl. 1.*

VLADYKOV, VADIM D. 1949. Quebec lampreys (Petromyzonidae). I. List of species and their economical importance. *Dept. Fish., Quebec, Contrib. 26: 1–67, frontis. and figs. 1–21.*

——— 1950. Larvae of eastern American lampreys. I. Species with two dorsal fins. *Nat. Canadien, 77 (3–4): 73–94, figs. 1–13.*

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A New Species of Fish of the Genus *Blennius* from Florida[1]

WILLIAM N. TAVOLGA

THE following account is based upon seven specimens of a hitherto undescribed species of *Blennius* collected in the vicinity of Marine Studios, Marineland, Florida, in the summer of 1952. An additional specimen from Lemon Bay, Englewood, Florida, is also referred to this species.

Blennius nicholsi, sp. nov.

Figs. 1–4

DIAGNOSIS.—First dorsal spines greatly extended in males; supraorbital tentacles of males unbranched, smooth-edged (rudimentary in females); dorsal fin rays XII to XIII, 13 to 15; last ray of dorsal joined to base of caudal; anal fin rays II, 16 or 17; upper canines present in males only; two oblique stripes leading from eye to angle of mouth and to gular region.

DESCRIPTION.—Size small; largest male 44 mm. in standard length. Body form moderately slender and compressed; depth at 4th dorsal spine 3.3 to 3.8 in standard length.

Head length of posterior angle of operculum 3.2 to 3.7 in standard length; depth at 2nd dorsal spine 3.7 to 3.9. Snout short, profile nearly vertical; length 5 to 7 in head, and about 1.5 in eye. Eye diameter 4 in head; interorbital space concave, 2 to 3 in eye. Mouth small, low-set and horizontal; length of upper jaw equal to or slightly more than eye. Lips broad and thickened, with deep groove above upper lip. Anterior naris at end of a short tube with a small triangular dorsal flap; posterior naris a simple oval aperture.

Supraorbital tentacle in males unbranched, smooth-edged, flat and lanceolate; length from ½ to 2 times eye diameter; rudimentary in females.

Teeth with long, slender pedicels; numbering 21–23/19–21. Lower canine present in both sexes; strongly curved and larger in males. Upper canine present in mature males only; pointed, slightly curved and equal to or slightly larger than last incisor.

Lateral line continuous anteriorly, extending caudad to the level of 6th to 11th dorsal spines. Head pores and lateral line of holotype and allotype are shown on Figs. 3 and 4.

Dorsal fin rays XII to XIII, 13 to 15; last ray joined to base of caudal. In mature males the first 4 or 5 spines greatly elongated and with free ends; spines and rays subequal in females and immature males; last dorsal spine slightly shorter than first ray, producing a shallow notch along the fin margin.

Anal fin rays II, 16 or 17; spines and first ray usually thickened and fleshy in males; first spine in mature females short and embedded in the fleshy lips of the urogenital aperture; second spine short and broad at the base in females.

Pectoral fin with 13 rays, extending to level of anus or just beyond. A low, scarcely distinct vertical fold of skin extends from dorsal margin of base of pectoral. Caudal fin with 13 or 14

[1] This work was aided, in part, by a research grant from the Marineland Research Laboratory, Marineland, St. Augustine, Florida.

principal rays; length 4.8 to 5.3 in standard length.

The number of vertebrae, as estimated from myotome counts, approximates 32 to 35 (11–12 + 21–23).

Coloration olivaceous grey-green in life (brownish in alcohol). Males very dark, with 8 to 12 indistinct light lines extending obliquely caudad just below dorsal fin; fins dark olive; no ocellus on anterior dorsal fin. Females and young specimens lighter, with fine whitish reticulations on sides and dorsum; small whitish spots arranged in three irregular rows on sides of body and tail; fins light. Head with two dark stripes leading down from pupil; one to angle of mouth and the other curving down to gular region; both these stripes broaden ventrally and break up into small round spots; lips with vertical dark brown bars. Head markings more distinct in females, contrasting with the lighter ground color.

TYPES.—The holotype, AMNH No. 19863, is a mature male, 44 mm. in standard length. The allotype, AMNH No. 19864, is a mature female, 42 mm. in standard length. These two specimens were collected from oyster shells in tide pools at Matanzas River Inlet, about 3 miles north of Marineland, and 15 miles south of St. Augustine, Florida, in June, 1952, by the writer.

There are six paratypes as follows: A mature

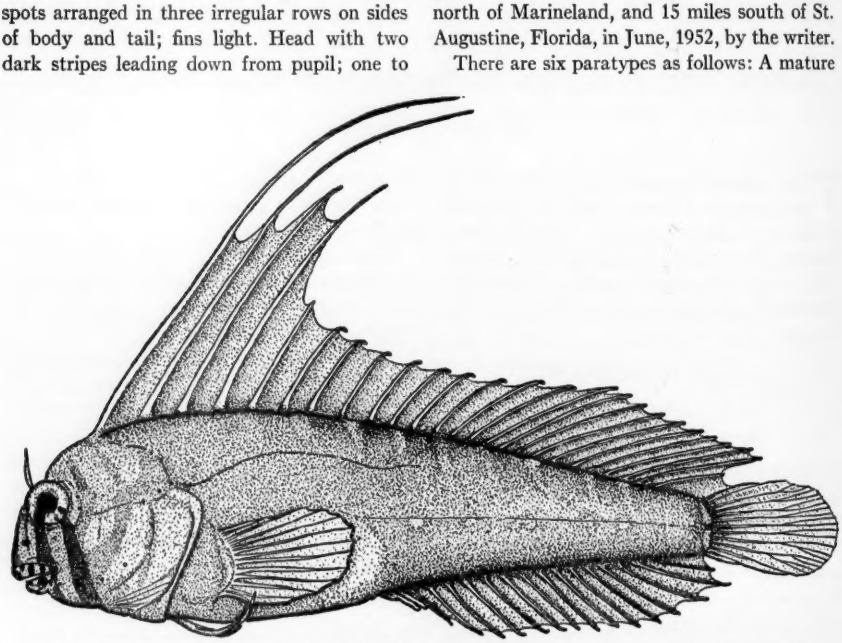

Fig. 1. Holotype of *Blennius nicholsi*, AMNH No. 19863, mature male, 44 mm. in standard length.

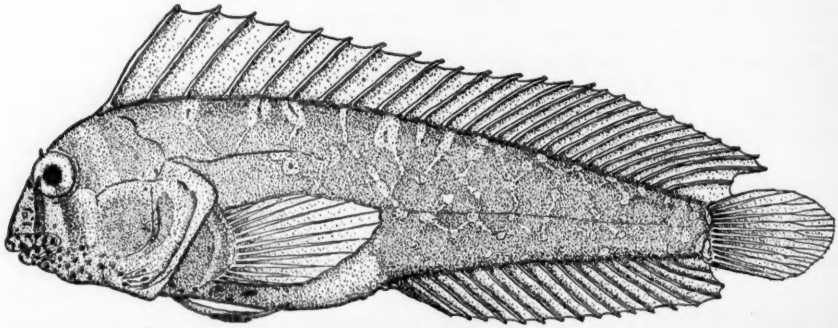

Fig. 2. Allotype of *Blennius nicholsi*, AMNH No. 19864, mature female, 42 mm. in standard length.

male, 33.5 mm. in standard length, collected at Matanzas River Inlet in June, 1952, by F. G. Wood, Jr.; CNHM No. 47919. A mature male, 31 mm. long, from Lemon Bay, Englewood, Florida, taken by Stewart Springer in 1937; CNHM No. 50563. (The first two paratypes were loaned to the writer through the courtesy of Mr. Loren P. Woods, Chicago Natural History Museum.) An immature male, 30 mm. long, collected at Matanzas River Inlet, June, 1952, by F. G. Wood, Jr.; AMNH No. 19865. An immature female(?), 19 mm. long, a mature(?) female, 25 mm. long, and a mature(?) female 23 mm. long, AMNH No. 19866, collected in a small branch of the Matanzas River, about a half mile west of Marineland, in August, 1952, by the writer.

VARIATIONS.—Table I summarizes the variations in proportions and fin-ray counts among the type specimens.

In the females and the immature male, the supraorbital tentacles are minute papules or flaps not over one-tenth the eye diameter. In the Englewood male, they are longest, almost twice the eye diameter. In the holotype and the largest paratype, the tentacles are one-half the eye diameter and equal to it, respectively.

Canine teeth on the upper jaw are present only in the three mature males (holotype and first two paratypes), and they vary in size only slightly. The lower canines are present in all of the specimens, but their size varies considerably with the sex and size of the animal, as follows: Holotype, 2.5 times the length of the last incisor; strongly recurved. Allotype, 1.5 times last incisor; slightly recurved. Male, 33.5 mm., projecting slightly above level of last incisor; slightly recurved. Male, 31 mm., 2.5 times last incisor; strongly recurved. Male, 30 mm., 1.3 times last incisor; slightly recurved. Female(?), 19 mm., barely projecting over edge of dentary. Female, 25 mm., projecting slightly over last incisor; uncurved. Female, 23 mm., equal to last incisor; slightly recurved.

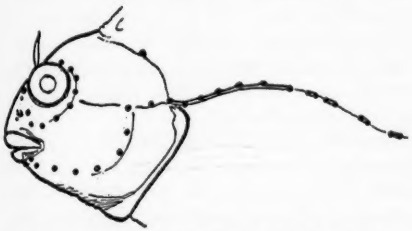

Fig. 3. Holotype of *Blennius nicholsi*, showing lateral line and distribution of head pores.

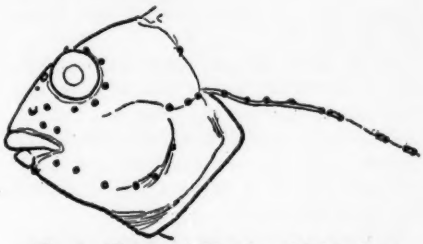

Fig. 4. Allotype of *Blennius nicholsi*, showing lateral line and distribution of head pores.

TABLE I

MEASUREMENTS AND COUNTS OF *Blennius nicholsi*

Item	Holotype	Allotype	Paratypes					
Standard length (mm.)	44	42	33.5	31	30	19	25	23
Dimensions in standard length:								
Body depth at 4th dorsal spine	3.7	3.8	3.7	3.6	3.3	3.5	3.6	3.8
Head length	3.7	3.5	3.4	3.4	3.3	3.2	3.5	3.5
Head depth at 2nd spine	3.7	3.7	3.9	3.7	3.8	3.8	3.8	3.8
Longest pectoral rays	4.4	4.2	4.5	3.9	?	3.8	3.8	4.6
Longest caudal rays	4.9	4.9	4.8	4.8	?	4.8	5.0	5.3
First dorsal spine	1.7	6.0	1.8	2.1	7.5	6.3	8.3	7.7
Number of fin rays:								
Dorsal spines	XII	XIII	XII	XII	XII	XII	XII	XII
Dorsal rays	13	14	15	14	15	15	15	15
Anal spines	II	(I)I	II	II	II	II	(I)I	(I)I
Anal rays	16	17	17	16	17	17	17	17

TABLE II

MEASUREMENTS OF DORSAL SPINES IN THREE MALES OF *Blennius nicholsi*

Spine	Holotype	Paratypes	
	44 mm.	33.5 mm.	31 mm.
Length of spine in standard length:			
First	1.7	1.8	2.1
Second	1.7	1.8	2.2
Third	2.3	2.6	2.5
Fourth	2.3	5.6	6.2
Portion of spine free from fin membrane:			
First	2/3	3/4	1/3
Second	2/3	2/3	2/3
Third	1/3	2/3	3/10
Fourth	1/3	Tip	Tip

The anterior dorsal spines are elongated in the three mature males (holotype and first two paratypes), and the variations in the proportional length and free sections of these spines are summarized in Table II.

In the males, the anal spines and first anal ray are only slightly shorter than the succeeding rays. In the holotype, the spines and first ray are thickened along their entire length; in the 31-mm. male, they are thickened and fleshy only at their distal thirds; in the 33.5- and 30-mm. males, they are unmodified.

In the females, the first anal spine is short and often difficult to see. The first spine of the allotype is almost completely enclosed by the thickened, fleshy lips of the urogenital pore, and the second spine is short and broad at the base. In the 25- and 23-mm. females, the first spine is only partially enclosed by the urogenital lips and the second spine is only slightly shorter than the succeeding rays. The 19-mm. female(?) has an unmodified second spine and the first spine is short and thickened at its base.

RELATIONSHIPS.—This species is readily distinguishable from other Atlantic Coast *Blennius*. The males are particularly distinct by virtue of their elongate anterior dorsal spines and unbranched supraorbital tentacles. Following is a tentative key to the species of *Blennius* from Florida.

I. Nape with a series of cirri. . . . . *Blennius cristatus* Linnaeus.

II. Nape without cirri.

A. Dorsal fin XII, 21–22; supraorbital tentacle long and fringed. . . . . *Blennius pilicornis* Cuvier.

B. Dorsal fin with fewer than 20 soft rays.

1. Supraorbital cirrus long and branched; dorsal fin XI–XII, 17–18, with spines as long as or slightly longer than rays. . . . . *Blennius marmoreus* Poey.

2. Supraorbital cirrus small, simple or rudimentary; dorsal fin XII–XIII, 13–15, with the first spines greatly elongated in males. . . . . *Blennius nicholsi* Tavolga.

In the above key, *Blennius marmoreus* is considered to include *B. stearnsi* Jordan and Gilbert, *B. favosus* Goode and Bean, and probably *B. fucorum* C. & V., as suggested by Longley and Hildebrand (1941: 266).

The type of the inadequately known *Blennius vinctus* Poey, from Cuba, is described by Jordan and Evermann (1898: 2382). The extended posterior dorsal rays and fringed supraorbital cirrus separate this species from *B. nicholsi*.

A more northern species, *Blennius foxi* Fowler (1914: 344), is characterized by a large supraorbital cirrus with small branches, dorsal and anal fins not connected to caudal, broad black bands on the body, 14 pectoral rays, ventral fin rays I,3, and other points of difference from *B. nicholsi*.

The position of *B. nicholsi* within the genus *Blennius* is not clear. According to Norman's (1943: 800) diagnoses of the subgenera, the present species may be allocated to either of the subgenera *Salaria* or *Blennius*.

The subgenus *Blennius* comprises the type species, *B. ocellaris* Linnaeus, and the recently described *B. normani* Poll (1949: 244), from the Congo River, Angola. The latter species is very similar to *B. ocellaris*, but differs from the subgeneric diagnosis (Norman, *loc. cit.*) in lacking a fringed flap below the first dorsal spine and possessing a more continuous lateral line.

The subgenus *Salaria* contains a large share of the widely distributed and highly variable species. All the North American forms evidently belong to this group.

The presence of a well developed supralabial groove, long and slender premaxillary pedicels, 13 pectoral rays, and the anteriorly continuous lateral line in *B. nicholsi* appears to place it in the subgenus *Salaria*, as defined by Norman. On the other hand, *nicholsi* resembles *ocellaris*

in the elevated anterior dorsal spines, the smaller number of caudal vertebrae, and the lack of fleshy, dendritic masses on the anal spines of the males.

In regard to the allocation of *B. nicholsi* to any of the subgenera or species groupings suggested by Norman, it seems unwise to attempt this without a considerable amount of comparative material from the Mediterranean and Pacific regions, and especially since the American blennies as a whole are in need of review.

ACKNOWLEDGEMENTS.—The author is greatly indebted to Mr. John T. Nichols, of The American Museum of Natural History (AMNH), for his aid and encouragement, and also for making specimens of other species under his care available for comparison. Mr. Loren P. Woods, of the Chicago Natural History Museum (CNHM), was kind and helpful in his advice and loan of specimens. I also wish to thank Dr. Charles M. Breder, Jr. for reading and commenting upon the manuscript. Mr. F. G. Wood, Jr., and Mr. Frank S. Essapian, of Marine Studios, Marineland, Florida, aided in the collection of the material.

LITERATURE CITED

FOWLER, HENRY W. 1914. Description of a new blenny from New Jersey, with notes on other fishes from the middle Atlantic states. *Proc. Acad. Nat. Sci. Phila., 66: 342–58.*

JORDAN, DAVID STARR, AND BARTON W. EVERMANN. 1898. The fishes of North and Middle America. *Bull. U. S. Nat. Mus., No. 47, pt. III: i–xxiv, 2183–3136.*

LONGLEY, WILLIAM H., AND SAMUEL F. HILDEBRAND. 1941. Systematic catalogue of the fishes of Tortugas, Florida, with observations on color, habits, and local distribution. *Papers Tortugas Lab., vol. 34, Carnegie Inst. Wash. Publ. No. 535: i–xiii, 1–331.*

NORMAN, J. R. 1943. Notes on the blennioid fishes. – I. A provisional synopsis of the genera of the family *Blenniidae. Ann. & Mag. Nat. Hist., ser., 11, 10: 793–812.*

POLL, MAX. 1949. Résultats scientifiques des croisières du navire-école belge "Mercator." Tome IV. Part IV. Poissons. *Mém. Inst. Roy. Sci. Nat. Belgique, Ser. 2, Fasc. 33: 173–268.*

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Geographic Variation in the Pacific Herring[1]

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ALONG the west coast of North America the Pacific herring, *Clupea pallasi* Valenciennes, ranges from the Bering Sea to southern California. In the waters of Alaska and British Columbia, this species supports commercial fisheries of major importance. As a consequence, the herring has been investigated intensively, and the major features of its life history have been rather well worked out.

An important phase of early studies of variation in herring concerned the extent to which the stocks in the various fishing areas were independent of each other. Since at that time no satisfactory method of tagging herring was known, it was necessary to follow the methods developed by Heincke (1898), based on studies of mean numbers of vertebrae and fin rays, body proportions, growth rates and various other characters. Thompson (1917) found marked differences in mean numbers of vertebrae and anal rays in samples from British Columbia and California. Hubbs (1925) extended and confirmed the work of Thompson. Rounsefell (1930), in a thorough investigation of latitudinal variation, based on examination of a large number of samples from localities covering the entire geographic range of the species, showed that the mean numbers of vertebrae vary from 54.67 at the Shumagin Islands to 50.68 at San Diego. He was not able to demonstrate a regular latitudinal variation in mean numbers of dorsal or anal rays, although some differences were found between distant localities. Differences in head length, growth rate, size and age composition, condition, and spawning season, corroborated in general the conclusions derived from vertebral counts.

[1] Contributions from the Scripps Institution of Oceanography, New Series, No. 667.

[2] Now Director, Virginia Fisheries Laboratory, Gloucester Point, Virginia.

Tester (1937a) examined a large series of samples from British Columbia waters and for this region concluded that the mean numbers of vertebrae decrease from north to south. He also found differences between localities in the mean numbers of ventral scutes, sex ratios, rates of growth in length, proportional head lengths, and age composition.

In general, these investigations appeared to have shown that the most satisfactory character for the detection of population differences in the Pacific herring was the mean number of vertebral centra. Probably for this reason the authors cited above did not make equally thorough studies of other characters. Subsequent studies on herring populations (Chapman, Katz, and Erickson, 1941; McHugh, 1942; Tester, 1949) have employed vertebral counts exclusively. In the northern anchovy (*Engraulis mordax mordax*), however, it has been found that counts of fin rays and gillrakers provide useful additional information on the population structure of the species (McHugh, 1951). Since precise enumeration of dorsal and anal rays is difficult in the clupeoid fishes (McHugh, 1951), the various investigators have hesitated to compare their counts with counts given by previous workers. Thus Rounsefell (1930) did not utilize the prior records of Thompson (1917) and Hubbs (1925), and consequently our knowledge of latitudinal variation in these characters is incomplete. Furthermore, although Schnakenbeck (1927) found that mean numbers of pectoral rays were useful in separating populations of Atlantic herring (*Clupea harengus*), Tester (1937a) appears to have been the only investigator who has studied this character in *C. pallasi*. Tester also has presented some data on the numbers of ventral scutes (keeled scales) in Pacific herring. No attention whatsoever seems to have been paid to variation with latitude in mean numbers of gillrakers.

The author has had occasion to examine many samples of Pacific herring from Alaska to southern California in a detailed study of the structure of the vertebral column.[3] Incidental to this investigation, counts of dorsal, anal, and pectoral rays, ventral scutes, and gillrakers usually were recorded. A large series of dried vertebral columns of herring from British Columbia waters was provided by Dr. A. L. Tester. Thanks are due also to Lawrence N. Kolloen of the U. S. Fish and Wildlife Service, Dr. Frances N. Clark, Julius B. Phillips, and Anita Daugherty of the California State Fisheries Laboratory, and Dr. and Mrs. Carl L. Hubbs of the Scripps Institution of Oceanography for assistance in securing samples.

[3] McHugh, J. L. 1950. Variations and populations in the clupeoid fishes of the North Pacific. Doctoral dissertation, Univ. Calif., Los Angeles, 116 pp.

Sexual Dimorphism

Tester (1937a) stated that, on the average, female Pacific herring are larger than males. Presumably it follows that the rate of growth in females is somewhat greater, although Tester (1937b) did not confirm this point. Age determinations from scales of California herring show that females are larger than males of equal age. Tester (1937a) also demonstrated statistically significant differences in sex ratio between certain localities.

No evidence of sexual dimorphism in meristic characters of Pacific herring has been reported. Analysis of data gathered during the present study has not revealed any real difference between the sexes in mean numbers of vertebral centra, dorsal, anal, or pectoral rays, gillrakers, or ventral scutes (Table I).

The Number of Vertebral Centra

In general, the mean numbers of vertebral centra in samples of Pacific herring decrease from north to south (Table II). Little can be added to the extensive body of data provided by Thompson (1917), Hubbs (1925), Rounsefell (1930), Rounsefell and Dahlgren (1932, 1935), Tester (1937a, 1949), Chapman, Katz, and Erickson (1941), and McHugh (1942), except to point out certain interesting irregularities in the latitudinal cline. Although the highest mean reported by Rounsefell (1930) for Alaskan waters was 54.67, this sample came from the Shumagin Islands, off the Alaskan peninsula, almost 10 degrees of latitude south of Golovin Bay in the Bering Sea, where the mean (52.79) was almost two vertebrae less. Carl L. Hubbs (personal communication) believes that Rounsefell's sample from the Shumagin Islands represents a pelagic type, either a strongly marked race of *C. pallasi* or perhaps a Pacific population of *C. harengus*. Berg (1948) regarded *C. pallasi* as a subspecies of *C. harengus*. The

TABLE I

MEAN NUMBERS OF DORSAL, ANAL, AND PECTORAL RAYS, VENTRAL SCUTES, AND GILLRAKERS IN MALE AND FEMALE PACIFIC HERRING FROM THE WEST COAST OF NORTH AMERICA

Locality and Character	Males			Females		
	Mean	Number	$\Sigma(x-\bar{x})^2$	Mean	Number	$\Sigma(x-\bar{x})^2$
Alaska:						
Dorsal rays	18.54	110	45.27	18.48	114	54.47
Anal rays	16.84	111	59.08	16.75	114	65.12
Pectoral rays	17.56	111	43.37	17.55	114	52.18
Ventral scutes	11.91	46	17.65	11.93	54	33.70
Gillrakers[1]	45.66	136	308.45	45.70	139	311.31
California:						
Dorsal rays	18.57	566	277.08	18.59	379	189.43
Anal rays	15.99	564	443.94	15.95	373	291.13
Pectoral rays	17.14	565	387.23	17.06	378	241.60
Ventral scutes	11.79	566	349.13	11.89	382	230.72

[1] Combined data from Alaska and California.

mean value most closely approaching that of the Shumagin Islands sample, from Chignik (53.33), was more than one vertebra less than this extreme value. The herring population in the White Sea, which Hubbs (1925) and others consider to belong to the Pacific species, also has a lower mean number of vertebrae (53.56) than the Shumagin Islands sample.

The low numbers reported from the Bering Sea may arise principally as a result of the low

TABLE II

THE NUMBERS OF VERTEBRAL CENTRA IN SAMPLES OF PACIFIC HERRING FROM THE WEST COAST OF NORTH AMERICA

Locality	Date	Numbers of vertebral centra							Mean	Number	$\Sigma(x-\bar{x})^2$
		48	49	50	51	52	53	54			
Alaska:											
Shumagin Islands	Jul. 5, 1948	....	....	....	1	2	2	....	52.2	5	2.8
Port Dick	Jul. 11, 1948	....	....	....	1	30	54	10	52.77	95	38.91
Cape Kuliuk	Aug. 13, 1948	....	....	....	....	18	25	6	52.76	49	21.06
Bumble Bay	Aug. 6, 1948	....	....	....	....	5	16	2	52.87	23	6.61
Bumble Bay	Sept. 15, 1948	....	....	....	3	16	25	4	52.62	48	25.25
Prince William Sound	Summer 1948	....	....	....	2	34	53	8	52.69	97	40.72
McLeod Harbor	Summer 1948	....	....	....	....	13	24	3	52.75	40	13.50
California:											
Humboldt Bay	May 5, 1948	....	....	2	18	12	1	....	51.36	33	13.64
Tomales Bay	Jan. 17, 1947	....	....	7	61	31	1	1	51.29	101	42.67
San Francisco Bay	Jan. 8, 1947	....	3	36	52	15	....	....	50.75	106	56.12
San Francisco Bay	Jan. 22, 1948	....	....	39	82	13	1	....	50.82	135	51.73
Monterey Bay	January 1947	....	2	50	109	25	....	....	50.84	186	78.48
Monterey Bay	May 15, 1947	....	1	30	75	29	2	....	51.01	137	70.99
Monterey Bay	Sept. 10, 1947	....	2	30	64	15	....	....	50.83	111	49.75
San Pedro	Mar. 31, 1950	....	....	9	12	6	....	....	50.89	27	14.67
San Diego Bay	Dec. 5, 1946	1	4	54	82	16	3	....	50.73	160	95.44
San Diego Bay	Jan. 16, 1948	....	....	2	4	1	....	....	50.86	7	2.85

salinities in this region, for it has been shown that in several fishes, including *Zoarces viviparus*, (Schmidt, 1917, 1920), mean numbers of vertebrae vary directly as the salinity of the water. Barnes and Thompson (1938) reported that salinities along the Alaska coast in the Bering Sea are abnormally low due to river dilution, and LaFond and Pritchard (1952) demonstrated the striking increase in water temperature and decrease in salinity from the western to eastern Bering Sea. Chapman, Katz, and Erickson (1941) have shown that the mean numbers of vertebrae in herring from Puget Sound decrease rather markedly from the entrance to the head of the Sound. This is perhaps also a result of the decreasing salinities associated with land drainage in this region. Nevertheless, the Shumagin Islands population sampled by Rounsefell (1930) exceeds any known population of Pacific herring in mean vertebral number by an appreciable amount. This population must be extremely localized in its distribution, for a small sample of herring obtained from the Shumagin Islands in 1948 had the following counts: 51 (1), 52 (2), 53 (2), a distribution that scarcely would be expected in a sample drawn from the population sampled by Rounsefell ($t = 5.91$, P about 1 in 5×10^8).

Subsequent studies have shown that postlarval and young herring from certain localities in southern British Columbia sometimes have unusually high numbers of vertebrae. In the 1936 year-class, for example, means of 52.71 and 52.64 were encountered in two samples comprising 349 fish (McHugh, 1942). These are considerably higher than any means previously or since reported along the entire British Columbia coast. This phenomenon was reported without particular comment, for it was known that extreme tidal mixing of the waters in the southern part of the Strait of Georgia leads to relatively low water temperatures and high salinities in this area, and such conditions have been reported to produce high numbers of vertebrae (Schmidt, 1917, 1920; Tester, 1938).

Investigating populations of herring in adjacent waters off the Washington coast, Chapman, Katz, and Erickson (1941) reported equally high numbers of vertebrae in samples of adult herring from East Sound on Orcas Island. Sixty-five four-year-old fish (1933 year-class) had an average of 52.63 vertebrae, and 102 five-year-old fish (1932 year-class), 52.76. Other samples from the same general area, some taken only a few miles away, were normal for this region, having on the average about a whole vertebra fewer than the East Sound sample.

The maintenance of unusually high mean vertebral numbers in adults in regions where the species is rather abundant is surprising. Apparently the schools of herring belonging to these populations do not intermingle with the main bodies of herring in the vicinity throughout their life, or if mixture does occur, complete resegregation is effected at spawning time. Although the number of vertebrae in the Pacific herring apparently is subject to modification by environmental factors, such as temperature, during early development (Rounsefell and Dahlgren, 1932; Tester, 1938; McHugh, 1942), the degree of isolation to which these groups of fish almost certainly are subject, together with their remarkably high vertebral counts, suggests possible racial status. The high mean numbers of vertebrae found in postlarvae of the 1936 year-class in certain waters of southern British Columbia suggest that this race of herring does not necessarily spawn always in exactly the same place. Although herring schools sometimes are highly heterogeneous in composition, as shown by the recovery of tags from several different areas in one boatload of herring (Tester, 1949), it must be inferred from the evidence given above that some schools of fish remain remarkably stable throughout life. Similar evidence of an indirect nature was noted during studies of the northern anchovy (see footnote 3), when in one small sample, taken off San Diego in 1949, essentially identical abnormalities of the vertebral centra appeared at the same location on the vertebral columns of four fish in twenty-five. This phenomenon was the more striking because fusions and other abnormalities of the vertebral centra are very infrequent in *Engraulis mordax mordax*.

The Number of Precaudal and Caudal Vertebrae

From counts made on samples of Pacific herring from British Columbia waters, Tester (1937a) concluded that mean numbers of caudal vertebrae do not vary with latitude. Thus, the decrease in mean numbers of vertebrae from north to south is confined entirely to the precaudal region. In general, this also was

TABLE III

MEAN NUMBERS OF PRECAUDAL AND CAUDAL VERTEBRAL CENTRA IN SAMPLES OF PACIFIC HERRING

Locality	Numbers of fish	Precaudal vertebrae	Caudal vertebrae	Total vertebrae
Alaska:				
Port Dick	95	23.97	28.77	52.74
Cape Kuliuk	50	23.94	28.80	52.74
Bumble Bay	72	23.75	28.94	52.69
Prince William Sound	97	23.87	28.84	52.71
McLeod Harbor	40	23.82	28.92	52.74
British Columbia:				
Jap Inlet	104	23.85	28.37	52.22
Duncan Bay	215	23.71	28.62	52.33
Myers Pass	95	23.78	28.34	52.12
Deer Passage	103	23.63	28.48	52.11
Laredo Inlet	93	23.72	28.48	52.20
Kwakshua Pass	100	23.61	28.49	52.10
Smith Inlet	213	23.25	28.62	51.87
Nootka Sound	326	23.17	28.58	51.75
Barkley Sound	362	23.18	28.68	51.86
Nanoose Bay	189	23.06	28.72	51.78
Hammond Bay	81	23.21	28.48	51.69
Departure Bay	115	22.92	28.76	51.68
Dodd Narrows	98	23.16	28.63	51.79
Ladysmith Harbor	121	23.04	28.80	51.84
Mill Bay	125	23.07	28.74	51.81
Cowichan Bay	90	23.17	29.06	52.23
Swanson Channel	220	23.18	28.69	51.87
Fulford Harbor	100	23.04	28.79	51.83
California:				
Tomales Bay	101	22.31	28.98	51.29
San Francisco Bay	106	22.07	28.65	50.72
Monterey Bay	417	22.39	28.50	50.89
San Diego Bay	163	22.52	28.23	50.75

true for young British Columbia herring, although the two samples with unusually high means did not conform with this pattern (McHugh, 1942). Analysis of variance of the mean numbers of caudal vertebrae in all samples herein reported from Alaska, British Columbia, and California indicates that these samples could not have been drawn from the same population ($F = 4.08$, $F_{0.01} = 1.61$). However, although the means tend to decrease slightly from north to south (Table III), the latitudinal trend is very irregular (Fig. 1), and the rather highly significant F value is due largely to this apparently random variation. The average difference in mean numbers of caudal vertebrae between Alaska and southern California is only 0.38 vertebra. The latitudinal trend in total numbers of vertebrae is caused almost entirely by a southward decrease in the numbers of elements in the precaudal portion of the vertebral column.

The relatively high mean numbers of caudal vertebrae in the samples from the 1936 year-class in Fulford Harbor and Patricia Bay, British Columbia (McHugh, 1942), further indicate the distinctness of this race of herring. The weighted mean number of caudal vertebrae (29.22) exceeds that of any other known population. A sample of postlarvae from Cowichan Bay (McHugh, 1942), representing the 1938 year-class, with 52.23 vertebral centra, was intermediate between the Fulford Harbor–Patricia Bay–East Sound race (52.70) and the typical southern British Columbia herring (51.80). If this Cowichan Bay sample were composed of a mixture of these two groups of herring, the expected mean number of caudal vertebrae would be about 28.95. Actually this sample had 29.06 caudal vertebrae, a value that does not differ significantly from expectation, suggesting that it was indeed a heterogeneous sample.

THE NUMBER OF DORSAL RAYS

According to Rounsefell (1930) the mean numbers of dorsal rays in samples of adult Pacific herring from Alaska to Puget Sound vary from 18.52 to 19.36. However, he found no regular trend with latitude, and concluded that populations cannot be distinguished on the

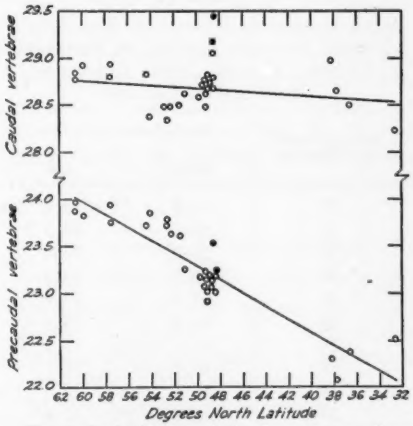

Fig. 1. Latitudinal variation in mean numbers of precaudal and caudal vertebral centra in *Clupea pallasi*. The lines have been fitted by the method of least squares. The black dots represent two samples from southern British Columbia (McHugh, 1942), and illustrate the unusually high caudal vertebral counts of the 1936 year-class in certain samples from this region. These two samples were not used in fitting the line.

basis of this character. Thompson (1917) and Hubbs (1925) reported means ranging from 18.03 to 18.42 in British Columbia and California waters.

As pointed out in a previous paper (McHugh, 1951), to obtain an accurate index of the number of rays in the median fins of clupeoid fishes, it is best to count only the principal rays. In the present study, both principal and total rays were recorded, but the condition of many of the samples was such that the tips of the anterior rays were broken, and only the total counts were considered reliable. As suspected by Rounsefell (1930), such counts on small fish may differ from those made on adults. For example, in the northern anchovy (McHugh, 1951), it has been shown that unless the rays have been stained with alizarin, the small anterior rays are sometimes missed. This is true also of the Pacific herring, for in a sample of late-stage postlarvae and small young from Humboldt Bay, California, the mean number of dorsal rays, as determined from the formalin-preserved sample, was 18.51, whereas after staining a mean count of 19.06 rays was obtained. Apparently the first unbranched ray was missed in about half the formalin-preserved specimens.

TABLE IV

MEAN NUMBERS OF DORSAL AND ANAL RAYS AT VARIOUS STANDARD LENGTHS IN POSTLARVAL PACIFIC HERRING FROM DEPARTURE BAY, BRITISH COLUMBIA

Standard length in millimeters	Mean numbers of fin rays	
	Dorsal	Anal
17	14.5	12.4
18	15.5	13.3
19	16.0	14.0
20	16.5	14.5
21	17.0	14.9
22	17.4	15.2
23	17.8	15.5
24	18.0	15.7
25	18.2	15.8
26	18.4	15.9
27	18.5	16.0
28	18.6	16.2
29	18.7	16.3
30	18.8	16.4
31	....	16.4
32	....	16.5

In a detailed study of the development of the dorsal rays in the Pacific anchovy (see footnote 3) it was concluded that the adult number of rays is not attained until the postlarvae reach a standard length of about 30 mm. Limited observations on the Pacific herring indicate that the dorsal rays are all developed at about the same standard length in this species. In British Columbia waters the young herring are about two and one-half months old at this size (McHugh, 1940). The addition of dorsal rays in two samples of postlarvae from Departure Bay, British Columbia, is illustrated in Table IV.

In a small sample from Humboldt Bay, California, ranging in standard length from 24 to 32 mm., the increase in number of dorsal rays with length is less obvious, but when these fish are divided into two lots according to standard length, the mean for the larger fish (28–32 mm.) exceeds the mean for the smaller (24–27 mm.) by 0.45 ray. A difference of this magnitude would occur by chance only once in about 100 trials. Although fish from the warmer southern waters might be expected to differentiate somewhat more rapidly than those from British Columbia, there is little evidence that the adult number of dorsal rays is formed at a standard length of less than 30 mm. in the Humboldt Bay region.

Original counts of dorsal rays are presented in Table V. The numbers of rays in adult herring from Alaskan waters compare closely with those reported by Rounsefell (1930). Although an analysis of variance suggests that the new samples from Alaska and California all could not have been drawn from the same population ($F = 4.14$, $F_{0.01} = 2.01$), there is no regular trend with latitude, and low or high mean values are about equally frequent in the northern and southern parts of the species range. There is no evidence from dorsal-ray counts that the Alaskan and California populations are distinct (Table V).

THE NUMBER OF ANAL RAYS

Rounsefell (1930) reported that mean numbers of anal rays in samples of adult Pacific herring from Alaska to Puget Sound vary from 17.31 to 16.47. He found that the mean numbers of anal rays vary irregularly with latitude, and concluded that, although statistically significant differences existed between certain localities, these differences were of un-

TABLE V

THE NUMBERS OF DORSAL RAYS IN SAMPLES OF PACIFIC HERRING FROM THE WEST COAST OF NORTH AMERICA

Locality	Numbers of dorsal rays						Mean	Number	$\Sigma(x - \bar{x})^2$
	16	17	18	19	20	21			
Alaska:									
Shumagin Islands	....	....	1	4	....	....	18.8	5	.....
Port Dick	....	2	37	53	7	....	18.66	99	40.32
Cape Kuliuk	....	2	24	21	3	....	18.50	50	22.50
Bumble Bay	....	5	42	23	2	....	18.31	72	29.28
Prince William Sound	....	....	3	1	1	....	18.6	5	.....
British Columbia:									
Departure Bay[1]	....	1	59	113	14	....	18.75	187	65.19
Satellite Channel[1]	....	2	46	56	7	....	18.61	111	44.34
California:									
Humboldt Bay	....	2	14	15	2	....	18.51	33	12.24
Tomales Bay	....	....	32	56	4	....	18.70	92	27.48
San Francisco Bay	1	9	89	115	19	1	18.62	234	123.15
Monterey Bay	1	22	201	208	23	....	18.52	458	228.28
Salinas River[1]	....	4	22	23	2	....	18.45	51	24.63
Los Angeles Harbor	....	....	11	14	3	....	18.71	28	11.72
San Pedro Harbor	....	3	30	42	6	....	18.63	81	36.89
San Diego Bay	....	11	61	83	13	....	18.58	168	88.83

[1] Immature fish.

certain value for the separation of populations. Thompson (1917) and Hubbs (1925) indicated a decrease from north to south, ranging from 16.57 in British Columbia to 15.91 in California.

Counts of anal rays are subject to the same sources of error already described for the dorsal fin. For the Humboldt Bay sample, the mean number of rays as determined before staining was 16.24; after staining, the mean was 16.42. Hence, as also in the northern anchovy (McHugh, 1951), the error introduced by occasional omission of the short anterior ray appears to be less for the anal than for the dorsal fin.

As in the anchovy (McHugh, 1951), the adult number of anal rays does not appear in Pacific herring until the postlarvae reach a standard length of about 30 mm. or somewhat more (Table IV). The Humboldt Bay sample, composed of fish ranging from 24 to 33 mm. in standard length, showed no regular increase in number of anal rays with length, but when the sample was divided in two parts according to length, the larger fish exceeded the smaller by an average of 0.38 ray.

Original anal-ray counts are summarized in Table VI. Analysis of variance of the means of the Alaska and California samples gave an F value of 18.54 ($F_{0.01} = 2.01$). The odds are very strongly against the hypothesis that these samples were drawn from the same population. The counts reported by Thompson (1917), Hubbs (1925), and Rounsefell (1930) appear to follow this trend rather closely, and support the conclusion that the mean numbers of anal rays decrease rather regularly from north to south (Fig. 2).

THE NUMBER OF PECTORAL RAYS

Tester (1937a) found no statistically significant differences in mean numbers of pectoral rays in samples of herring from British Columbia waters. The means in samples from nine localities varied from 17.55 to 17.68.

With reasonable care, enumeration of the numbers of pectoral rays is not subject to errors caused by failure to recognize all rays. In the present investigation, the left fin was removed and the rays counted under a dissecting microscope. It must be remembered that in the clupeoid fishes, the pectoral fin rays form rather

TABLE VI

THE NUMBERS OF ANAL RAYS IN SAMPLES OF PACIFIC HERRING FROM THE WEST COAST OF NORTH AMERICA

Locality	Numbers of anal rays							Mean	Number	$\Sigma(x - \bar{x})^2$
	13	14	15	16	17	18	19			
Alaska:										
Shumagin Islands	....	....	....	1	4	....	....	.....	5	.....
Port Dick	....	....	7	24	54	14	....	16.76	99	60.18
Cape Kuliuk	....	....	2	22	18	8	....	16.64	50	31.52
Bumble Bay	....	....	....	23	36	14	....	16.88	73	35.89
Prince William Sound	....	....	....	1	2	2	....	.....	5	.....
British Columbia:										
Departure Bay[1]	....	4	35	107	35	4	....	16.00	185	102.00
Satellite Channel[1]	....	....	7	40	57	6	....	16.56	110	53.05
California:										
Humboldt Bay	....	....	4	17	12	....	....	16.24	33	14.06
Tomales Bay	....	....	14	37	30	10	1	16.42	92	76.47
San Francisco Bay	....	9	45	116	52	11	....	16.05	233	176.48
Monterey Bay	1	14	96	222	106	13	1	16.02	453	327.86
Salinas River[1]	....	1	19	23	8	....	....	15.74	51	27.69
Los Angeles Harbor	....	1	7	5	11	4	....	16.36	28	34.43
San Pedro Harbor	....	....	7	26	39	8	....	16.60	80	49.20
San Diego Bay	1	12	71	67	15	....	....	15.50	166	101.50

[1] Immature fish.

late (see footnote 3), and the adult number usually is not attained until well after the transformation from postlarva to adolescent. Although it is not known exactly when the formation of pectoral rays is complete in the Pacific herring, the adult number certainly appears to be present at standard lengths in excess of 60 mm.

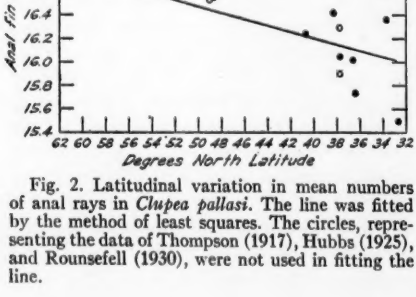

Fig. 2. Latitudinal variation in mean numbers of anal rays in *Clupea pallasi*. The line was fitted by the method of least squares. The circles, representing the data of Thompson (1917), Hubbs (1925), and Rounsefell (1930), were not used in fitting the line.

Analysis of variance of the means in Table VII shows that the samples could not have been drawn from the same population ($F = 10.88$, $F_{0.01} = 2.14$). In general the mean numbers of pectoral rays decrease from north to south (Fig. 3).

THE NUMBER OF VENTRAL SCUTES

Tester (1937a) showed that in British Columbia waters certain populations of herring may differ in the mean numbers of keeled scales (ventral scutes) lying between the bases of the pelvic fins and the anus. Variation in this character was irregular, however, and the means tended to increase from north to south.

Herring from Alaskan waters have slightly higher mean numbers of ventral scutes than herring from the California coast (Table VIII). The trend along the coast is irregular, however, for the San Diego fish had the highest mean of all samples examined. Excluding this sample, which differed widely from all others in several characters, the Alaska herring exceeded the California fish by an average of 0.20 ventral scute. This difference, 2.09 times greater than

TABLE VII

THE NUMBERS OF PECTORAL RAYS IN SAMPLES OF PACIFIC HERRING FROM THE WEST COAST OF NORTH AMERICA

Locality	Numbers of pectoral rays								Mean	Number	$\Sigma(x-\bar{x})^2$
	13	14	15	16	17	18	19	20			
Alaska:											
Shumagin Islands						5			18.00	5	.....
Port Dick				1	45	48	5	1	17.60	100	42.00
Cape Kuliuk				1	20	28	1		17.58	50	16.18
Bumble Bay				5	33	31	4		17.47	73	36.17
Prince William Sound					3	2			17.40	5	.....
British Columbia:											
Satellite Channel[1]			1	2	34	56	15	1	17.78	109	108.75
California:											
Tomales Bay			1	9	36	38	7		17.45	91	60.53
San Francisco Bay			2	40	119	62	9		17.16	232	140.41
Monterey Bay			5	62	245	124	21	1	17.21	458	278.46
Salinas River[1]			6	23	18	3			16.36	50	29.52
Los Angeles Harbor				5	14	8			17.11	27	12.67
San Pedro Harbor			1	5	16	5	1		17.00	28	18.00
San Diego Bay	1	0	6	69	80	10			16.55	166	85.11

[1] Immature fish.

its own standard error, could occur by chance about once in 27 trials. The unweighted mean of the British Columbia herring (Tester, 1937a) is 11.97 ventral scutes. There appears to be no regular trend in mean numbers of ventral scutes with latitude.

THE NUMBER OF GILLRAKERS

Previous workers have not discussed latitudinal variation in mean numbers of gillrakers in the Pacific herring. The most frequent number on the first arch in adults is 67 (21 + 46). Counts of rakers on the lower limb of this arch in a series of samples from Alaska, British Columbia, and California reveal no evidence that gillrakers continue to form throughout life, as they appear to do in the northern anchovy (McHugh, 1951), for no differences of great statistical significance can be demonstrated between the smaller and larger adults in the samples (Table IX). The limited data available suggest that the addition of rakers is complete shortly after the fish reach a standard length of 100 mm. (Fig. 4).

The California herring, though smaller, somewhat exceeded the Alaska fish in mean numbers of rakers (Table IX). Although the difference does not have great statistical significance ($t = 1.16$, $P = 0.23$), the smaller California fish probably did not all have the adult complement (Fig. 4). Furthermore, these southern herring have relatively larger heads, and therefore might be expected to have more rakers than those from northern waters.

FECUNDITY

Katz (1948) suggested that the numbers of mature ova in gravid females may be used to

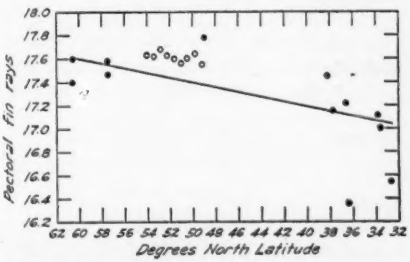

Fig. 3. Latitudinal variation in mean numbers of pectoral rays in *Clupea pallasi*. The line was fitted by the method of least squares. The circles, representing the data of Tester (1937a), were not used in fitting the line.

TABLE VIII

THE NUMBERS OF VENTRAL SCUTES (KEELED SCALES) BETWEEN THE BASE OF THE PELVIC FINS AND THE ANUS IN SAMPLES OF PACIFIC HERRING FROM THE WEST COAST OF NORTH AMERICA

Locality	Numbers of ventral scutes						Mean	Number	$\Sigma(x-\bar{x})^2$
	9	10	11	12	13	14			
Alaska:									
Shumagin Islands	....	....	....	1	....	....	.....	1	.....
Port Dick	....	....	1	3	2	....	.....	6	.....
Cape Kuliuk	....	....	11	30	5	2	11.96	48	23.91
Bumble Bay	....	1	12	26	5	1	11.84	45	23.91
Totals for Alaska	....	1	24	60	12	3	11.92	100	51.36
California:									
Tomales Bay	....	3	30	40	18	....	11.80	91	56.44
San Francisco Bay	1	10	91	111	18	1	11.59	232	123.91
Monterey Bay	....	28	121	229	72	1	11.77	451	285.48
San Diego Bay	....	....	15	102	54	3	12.26	174	69.36
Totals for California	1	41	257	482	162	5	11.82	948	581.51

differentiate between populations of Pacific herring. Since the numbers of maturing ova increase rapidly with size and age, it is necessary to examine a rather large and representative series of fish to obtain a reliable estimate of the relationship.

Although estimates were made of the numbers of ova in only 17 herring from California waters, these data are presented here for comparison (Table X). The two ovaries were removed and weighed, a sample weighing about one-twentieth of the entire mass was removed and weighed, and all mature eggs in this sample were counted. An estimate of the total number was derived by a simple calculation. The much larger number of immature eggs in the ovaries was not counted, on the assumption, perhaps unwarranted, that these would not have contributed to spawning in the year of capture.

From the limited data available, the increase

TABLE IX

THE NUMBERS OF GILLRAKERS ON THE LOWER LIMB OF THE FIRST ARCH IN SAMPLES OF PACIFIC HERRING FROM THE WEST COAST OF NORTH AMERICA

Locality	Standard length in mm.	Numbers of gillrakers										Mean	Number	$\Sigma(x-\bar{x})^2$
		41	42	43	44	45	46	47	48	49	50			
Alaska	167 – 213	1	0	5	16	26	29	14	12	1	....	45.64	104	217.84
	214 – 253	....	1	4	16	26	31	17	7	1	2	45.69	105	218.25
California	101 – 141	....	....	1	4	13	6	4	2	1	....	45.58	31	53.55
	142 – 177	....	....	2	4	5	9	5	3	1	3	46.22	32	111.47
Totals:														
Small fish	101 – 213	1	0	6	20	39	35	18	14	2	....	45.63	135	271.48
Large fish	142 – 253	....	1	6	20	31	40	22	10	2	5	45.82	137	336.44
Totals:														
Alaska	167 – 253	1	1	9	32	52	60	31	19	2	2	45.67	209	436.22
California	101 – 177	....	....	3	8	18	15	9	5	2	3	45.91	63	171.43

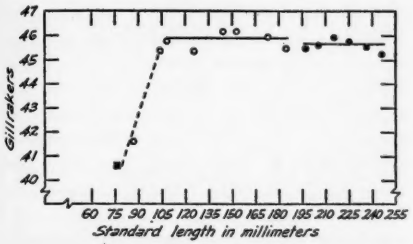

Fig. 4. Mean numbers of gillrakers on the lower limb of the first arch in *Clupea pallasi*. The formation of the rakers appears to be complete at a standard length of about 100 mm. Fish from Alaska are represented by black dots; British Columbia, black square; California, circles. The broken line was fitted by eye. The two horizontal lines represent the mean values for California and Alaska respectively.

in number of ova with increasing length of fish appears to be much less pronounced in herring from southern California waters than in the same species from the Washington coast. The smaller females had more eggs, and the larger individuals fewer, than those in the Seal Rock samples. Egg production in these relatively small California fish is approximately equivalent to the numbers reported by Hart and Tester (1934) for British Columbia herring, and Ambroz (1931) for Siberian fish, of equal size. The tendency for larger fish to produce more eggs, as demonstrated by Katz and Erickson (1950), is not especially pronounced in this small sample of California herring.

With respect to age, the California herring produce fewer eggs than herring from other localities. One fish from San Francisco Bay in its fourth year contained only 13,279 eggs, and three from the same locality in their fifth year of life contained an average of only 21,762. At the same ages the Washington herring contained 26,414 and 38,376 eggs respectively, Japanese herring 33,661 and 39,825, and Siberian herring 96,096 and 102,610. Since the Pacific herring in California waters apparently does not reach lengths as great as those reported for more northern waters, it appears that the average annual egg production per female is lower. Perhaps this is somewhat counterbalanced by an earlier maturity, or perhaps by several spawnings in a season.

TABLE X

FECUNDITY OF FEMALE HERRING FROM SAN FRANCISCO AND SAN DIEGO BAYS

Standard lengths in millimeters	Average numbers of eggs	Numbers of fish
151 – 160	18,500	1
161 – 170	15,800	6
171 – 180	18,500	5
181 – 190	22,200	3
191 – 200	20,500	2

DISCUSSION AND CONCLUSIONS

As early as 1917 it had been established by Thompson that the Pacific herring was segregated into local populations along the Pacific coast of North America. Subsequent work by Hubbs (1925), Rounsefell (1930), Rounsefell and Dahlgren (1932, 1935), and Tester (1937a, 1949), further delineated these populations and confirmed the results of meristic studies by the more direct method of tagging. These findings have been used in formulating management policies for the commercial herring fisheries of Alaska and British Columbia.

For several reasons, these investigators laid particular emphasis on the mean numbers of vertebral centra as an index of the independence of populations. By indirect methods it has been inferred that the number of vertebrae is capable of modification by temperature during early development (Rounsefell and Dahlgren, 1932; Tester, 1938; McHugh, 1942), so that in any one locality the mean vertebral number may vary from year to year. This finding, however, has not invalidated the general conclusion that the number of vertebrae decreases from north to south. The latitudinal cline is by no means regular, however, for in more than one region samples taken in adjacent areas may differ sharply. At least one of these divergent populations appears to remain isolated from its neighbors throughout life, for the mature adults differ from nearby populations equally as much as do the postlarvae. This race does not always spawn in exactly the same locality, however, and the young may sometimes intermingle with the larger native population.

Although the Pacific herring spawns normally in the intertidal zone, or at the most only a few feet below low water, occasionally eggs have been found at some depth. In East Sound, for example, Chapman, Katz, and Erickson (1941) found Pacific herring eggs in 30 feet of water.

Perhaps some factor associated with depth plays a part in determining the high mean number of vertebrae in the East Sound population, and unusually high means in other areas, such as the Shumagin Islands in Alaska. It may be significant that the Atlantic herring differs chiefly from the Pacific species by reason of the greater depth at which it spawns, and its higher mean vertebral number. If a real relationship exists between these two characters, there would be even less reason to consider these herrings distinct species.

Other than temperature and salinity, the two most obvious factors that might have pronounced effects on embryonic development at different depths are pressure and light penetration. No evidence is available on the effects of hydrostatic pressure on herring development, although Goff (1940) stated that increased atmospheric pressure retards embryonic development in *Brachydanio rerio*. However, there is some reason to believe that the number of vertebrae in fishes may be influenced by light intensity during early development. Dannevig (1932) suggested that this is true for the cod (*Gadus callarias*), and some evidence indicating an inverse relationship between light intensity and mean numbers of vertebrae has been reported for *Leuresthes tenuis* (McHugh, 1954). Thus, in relatively deep water at least three factors, namely, low temperature, high salinity, and low light intensity, may produce high mean numbers of vertebrae.

Variation with latitude in the mean numbers of vertebral centra appears to be confined, contrary to a general rule, almost entirely to the precaudal section of the axial skeleton. The mean numbers of caudal vertebrae vary irregularly with latitude, and are unusually high in the samples from southern British Columbia having high total counts. This adds weight to the conclusion that a distinct and highly homogeneous race inhabits a restricted area in contiguous waters of British Columbia and Washington.

The Pacific herring differs from the Pacific northern anchovy (McHugh, 1951) in the apparent lack of sexual dimorphism in meristic characters and of a regular cline with latitude in mean numbers of dorsal rays or gillrakers. Mean anal and pectoral ray counts, however, tend to decrease from north to south, and the mean numbers of ventral scutes, though rather irregular, tend to follow a similar trend with latitude. It also appears that, in herring of equivalent size or age, females from northern waters produce greater numbers of eggs. These findings confirm the results of the more extensive investigations of vertebral numbers, in showing that the species tends to be segregated into a series of local populations. The San Diego population, lying at the extreme southern limit of the species range, is extreme in several characters, although it cannot be separated from other populations in southern California waters on the basis of mean vertebral numbers.

Ichthyologists have long suspected that the Atlantic and the Pacific herrings (*Clupea harengus* and *C. pallasi*) may be identical, or that, at the most, their differences warrant only subspecific separation (Berg, 1948). To settle this point would require the critical comparison of large series of fish, for both species inhabit a wide geographic range, and both are notably variable in meristic characters and in body form. Two points of difference that heretofore have seemed rather distinct are the depths of spawning and the mean numbers of vertebral centra (Tester, 1946). The Pacific herring spawns usually in the intertidal zone, the Atlantic species at some depth. Developing at considerable distances beneath the surface of the water, the eggs of the Atlantic herring are subject to relatively low light intensity, high salinity, and low temperature. These extremes all tend to produce high numbers of vertebrae, a characteristic feature of the Atlantic form.

The literature also appears to show that the two species differ in mean numbers of pectoral fin rays. Tester (1937a) reported mean values ranging from 17.55 to 17.68 for British Columbia herring, and Schnakenbeck (1927) gave a range of 16.56 to 16.82 for *Clupea harengus*. The San Diego and Salinas River herring, with 16.55 and 16.36 pectoral rays, resemble the Atlantic species in this respect. Thus, two points of difference between the herrings of the two oceans are less distinct than formerly supposed.

Literature Cited

Ambroz, A. J. 1931. The herring (*Clupea harengus pallasii* C. V.) of Peter the Great Bay. A biological sketch. *Bull. Pac. Sci. Fish. Inst., 6: 1–313.*

Barnes, C. A., and T. G. Thompson. 1938. Physical and chemical investigations in Bering Sea and portions of the North Pacific Ocean. *Univ. Wash. Publ. Oceanogr., 3(2): 35–9.*

BERG, LEO S. 1948. Freshwater fishes of the U.S.S.R. and neighboring countries. *Akad. Nauk, Moscow, 4th ed., vol. I: 1–466, figs. 1–281 (in Russian).*

CHAPMAN, W. M., M. KATZ, AND D. W. ERICKSON. 1941. The races of herring in the State of Washington. *State of Wash., Div. Sci. Res., Dept. Fisheries, Biol. Rept. 38A: 36 pp.*

DANNEVIG, A. 1932. Is the number of vertebrae in the cod influenced by light or high temperature during the early stages? *Jour. Cons., 7(1): 60–2.*

GOFF, RICHARD A. 1940. The effects of increased atmospheric pressure on the developing embryo of the zebra fish, *Brachydanio rerio* (Hamilton). *Trans. Kansas Acad. Sci., 43: 401–10.*

HART, JOHN LAWSON, AND ALBERT L. TESTER. 1934. Quantitative studies on herring spawning. *Trans. Amer. Fish. Soc., 64(1934): 307–12.*

HEINCKE, FRIEDRICH. 1898. Naturgeschichte des Herings. I: Die Lokalformen und die Wanderungen des Herings in den europaischen Meeren. *Berlin: 223 pp.*

HUBBS, CARL L. 1925. Racial and seasonal variation in the Pacific herring, California sardine and California anchovy. *Calif. Fish and Game Comm., Fish Bull. 8: 1–23.*

KATZ, MAX. 1948. The fecundity of herring from various parts of the North Pacific. *Trans. Amer. Fish. Soc., 75(1945): 72–6.*

——— AND DONALD W. ERICKSON. 1950. The fecundity of some herring from Seal Rock, Washington. COPEIA (3): *176–81.*

LAFOND, E. C., AND D. W. PRITCHARD. 1952. Physical oceanographic investigations in the eastern Bering and Chukchi Seas during the summer of 1947. *Jour. Mar. Res., 11(1): 69–86.*

MCHUGH, J. L. 1940. Growth of young herring in Departure Bay in 1939. *Fish. Res. Bd. Canada, Prog. Rept. Pacific Coast Stations, 43: 6–7.*

——— 1942. Vertebral number of young herring from southern British Columbia. *Jour. Fish. Res. Bd. Canada, 5(5): 474–84.*

——— 1951. Meristic variations and populations of northern anchovy (*Engraulis mordax mordax*). *Bull. Scripps Inst. Ocean., 6(3): 123–60.*

——— 1954. The influence of light on the number of vertebrae in the grunion, *Leuresthes tenuis*. COPEIA (*1*): *23–5.*

ROUNSEFELL, GEORGE A. 1930. Contribution to the biology of the Pacific herring, *Clupea pallasii*, and the condition of the fishery in Alaska. *Bull. U. S. Bur. Fish., 45: 227–320.*

——— AND EDWIN H. DAHLGREN. 1932. Fluctuations in the supply of herring, *Clupea pallasii*, in Prince William Sound, Alaska. *Ibid., 47: 263–91.*

——— AND EDWIN H. DAHLGREN. 1935. Races of herring, *Clupea pallasii*, in southeastern Alaska. *Ibid., 48: 119–41.*

SCHMIDT, JOHS. 1917. Racial investigations. I. *Zoarces viviparus* L. and local races of the same. *Compt.-Rend. Lab. Carlsberg, 13 (3): 279–397.*

——— 1920. Racial investigations. V. Experimental investigations with *Zoarces viviparus* L. *Ibid., 14 (9): 1–14.*

SCHNAKENBECK, W. 1927. Rassenuntersuchungen am Hering. *Ber. deutsch. wiss. Komm. Meeresforsch. N. F. 3 (2): 91–205.*

TESTER, ALBERT L. 1937a. Populations of herring (*Clupea pallasii*) in the coastal waters of British Columbia. *Jour. Biol. Bd. Canada, 3 (2): 108–44.*

——— 1937b. The length and age composition of the herring (*Clupea pallasii*) in the coastal waters of British Columbia. *Ibid., 3 (2): 145–68.*

——— 1938. Variation in the mean vertebral count of herring (*Clupea pallasii*) with water temperature. *Jour. Cons. Perm. Int. Expl. Mer., 13: 71–5.*

——— 1946. Comparison of the Atlantic and Pacific herring and herring fisheries. *Fish. Res. Bd. Canada, Prog. Rept. Pac. Coast Stations (66): 4–8.*

——— 1949. Populations of herring along the west coast of Vancouver Island on the basis of mean vertebral number, with a critique of the method. *Jour. Fish. Res. Bd. Canada, 7 (7): 403–20.*

THOMPSON, WILLIAM F. 1917. A contribution to the life-history of the Pacific herring: Its bearing on the condition and future of the fishery. *Rept. Brit. Col. Comm. Fish., 1916 (1917): 539–87.*

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Ichthyological Notes

FOOD STUDIES OF YOUNG SCIAENID FISHES, *MICROPOGON* AND *LEIOSTOMUS*, FROM NORTH CAROLINA[1].—Few studies of the food of young croakers, *Micropogon undulatus* (Linnaeus), and spot, *Leiostomus xanthurus* Lacépède, have been reported. Smith (1907, North Carolina Geol. and Econ. Surv., 2: 319) stated that Dr. Coker examined the stomach of twelve young croakers, 2 to 3.5 inches in length, and found copepods, amphipods, barnacles (cypris stage), ostracods and nematodes. Welsh and Breder (1923, Bull. U. S. Bur. Fish., 39 (1923–24): 183–4), studying croakers from Florida to Chesapeake Bay, found that crustaceans, molluscs, echinoderms and polychaete worms formed the bulk of their diet. They found considerable variation in the types of food taken in different localities. Gunter (1945, Publ. Inst. Mar. Sci., 1 (1): 73), examining 19 larger croakers 21 to 29 centimeters in length, found 12 stomachs empty and, of the remaining seven, one contained a fish; one, a mud shrimp (*Callianassa*); two, molluscs; one, a shrimp and a crab; and two contained only crabs.

Smith (*op. cit.:* 317) reported that spots eat

[1] Contribution No. 36 from the Institute of Fisheries Research, University of North Carolina.

TABLE I

FREQUENCY DISTRIBUTION OF FOOD ITEMS IN STOMACHS OF 159 CROAKERS AND 73 SPOTS, EXPRESSED AS PERCENTAGE OF FISH IN WHICH VARIOUS ITEMS WERE FOUND

Food item	Croaker	Spot
Diatoms	4.4	6.8
Foraminifera	...	13.7
Nematodes	0.6	71.2
Annelids	89.9	32.9
Crustaceans		
Ostracods	...	2.7
Copepods	25.2	100
Mysids	5.7	4.1
Amphipods	5.7	...
Decapods	3.1	5.5
Mites	...	1.4
Pelecypods	11.3	11.0
Fish	3.1	6.8*
Algae	...	8.2
Other Plants	...	23.3
Sand	...	41.1†

* Scales only.

† Represented as flat, spiral cases.

molluscs, crustaceans, annelids, sea urchins, small fish and seaweeds. Gunter (*op. cit.*: 71) examined six stomachs from spots of 200 to 212 millimeters in length and found only three containing food. The food in one was indistinguishable, one contained grass, and one contained amphipods. Welsh and Breder (*op. cit.*: 178–80) reported that the chief diet consists of small crustaceans. Hildebrand and Schroeder (1928, Bull. U. S. Bur. Fish. (1927) 43, Pt. 1: 272) listed crustaceans, annelids, molluscs, fish and vegetable debris as food of the spot.

The present study resulted from a desire to determine the food relationship, direct or indirect, between these two species of fish and the commercial species of shrimp in North Carolina waters. These fish were selected because an earlier study (Roelofs, 1950, Comm. Fish. Rev., 12 (8): 6) indicated that they comprise about 90 per cent of the benthonic fish population in Pamlico Sound and tributary waters.

Fish were collected from various localities and during all seasons of the year, except for the cold winter months when nearly all fish move out of the North Carolina estuaries into the warmer ocean waters. The stomachs of 159 croakers and 73 spots, that varied from 2½ to 6 inches long, were studied. Marked differences between the diets of the two species were found (Table I). These differences seem significant in view of the facts that these fish are both thought of as bottom-feeders and nearly all specimens of both species were collected at the same time and place. The differences therefore must result from factors other than differences in availability of food items.

Observations of feeding habits were made in the laboratory. Fish of both species were kept for a short time in an aquarium having about two inches of clean sand on the bottom. In searching for food the croakers, while swimming about three inches above the bottom, would suddenly dive into the bottom at a 30 to 45 degree angle, stop, back out, and continue swimming while "munching" the mouthful of "food." As they swam, sand dropped out of their mouths, and as soon as they had thoroughly investigated the last mouthful, they would dive for another. The spots, on the other hand, made a much shallower dive. They merely swam to the bottom, opened their mouths and, with the lower jaw, scooped up a mouthful of sand. This was done without stopping. Their subsequent handling of the "food" seemed no different from that of the croaker.

If these fish feed in nature as in the aquarium, certain of the differences in diet noted above can be understood. The croaker will obtain a larger proportion of organisms living *in* the bottom while the spot gets more of the organisms living *on* the bottom. Many of the annelid worms are burrowers and these may be taken by croakers using the feeding method described. Copepods and nematodes, when associated with the bottom, are more likely to be found *on* the bottom and therefore will be taken in larger numbers by the spot. The presence of large numbers of very small forms in the spot stomachs, however, pointed to the necessity of some sort of straining apparatus, whereas the relatively small numbers of these forms in the croaker stomachs could be taken incidentally.

A comparison of the gill structure of the two species showed that the spot possesses a much more efficient straining mechanism. The anterior edge of the first gill arch in both species supports long and slender gill rakers, 23 or 24 in the croaker and 30 or 31 in the spot. The posterior edge of the first arch and both sides of all other gill arches have modified gillrakers which are similar in basic structure but different in detail in the two species. In the spot, these rakers are in the form of fleshy knobs which are about three times longer than wide. The rakers on one arch alternate with those on the adjacent arch, as do the cogs on opposing gears, so that when the gill arches are compressed, a solid surface is presented. Each gillraker supports along its outer margin a row of 10 to 12 uniformly spaced, short, hair-like setae. When the gill arches are slightly separated as in breathing, the setae form a fine network which serves as a filter, holding back the small items of food while allowing the water to pass through. The gillrakers of the croaker are smaller and shorter and more or less triangular in shape, with the length about equal to the width at the base. The setae are also smaller and less numerous. Even when the gill arches are compressed,

there is considerable space through which water and small organisms may pass.

This difference in gill structure also aids in explaining the difference in diet. In fact, it seems possible that the spot may feed entirely above the bottom when there is a sufficient concentration of copepods and other planktonic organisms.

Quantitative food studies were not made, because in dealing with small fish the weight or volume of food could not be determined accurately. Certain general conclusions were reached, however. With the exception of the few small fish eaten by croakers, worms were by far the largest food items taken by that species. In several examples one worm filled the entire stomach, and it is estimated that annelid worms constituted at least 90 percent of the diet (on a volume or weight basis) of the croakers studied. In those spot stomachs that contained annelids, the worms constituted about 50 to 90 percent of the total contents, but two-thirds of the stomachs were without annelids. Some spot stomachs were literally filled with copepods and others contained a mixture of copepods, decapods, nematodes, diatoms, etc., with copepods always predominating. Of the stomachs examined, copepods constituted about 50 percent of the young spots' diet; annelids, 25 percent; and the balance was made up of the other forms listed. Nematodes were found in a large percentage of spot stomachs but, because of their relatively small numbers in individual stomachs and because of their very small size, they constituted an almost negligible part of the total food.

There were no apparent differences in the diet of either species with regard to locality, season of the year, or size of fish within the size range examined. The larger fish generally contained more food but of essentially the same variety as the smaller individuals.

Most of the collections were made when and where shrimp of the commercial species were known to be present. Two collections were made in small creeks where postlarval shrimp were being collected. However, no shrimp of the commercial species (*Penaeus setiferus*, *P. aztecus*, and *P. duorarum*) were found in the stomachs of either fish species. Shrimp taken by these fish were of the families Palaemonidae, Crangonidae, Sergestidae and Penaeidae. The latter family was represented by the genus *Sicyonia*. There does not seem to be a direct (predator-prey) food relationship, therefore, between these fish and the commercial shrimp. This study, however, does not preclude the possibility that larger fish might take some commercial shrimp. But considering the agility and armature of the shrimp and the observed feeding habits of these fish, it seems doubtful that the croaker and spot are important natural enemies of the commercial species of shrimp.—EUGENE W. ROELOFS, *Institute of Fisheries Research, University of North Carolina, Morehead City, North Carolina.*

PRESENCE OF AN AXILLARY VENOM GLAND IN THE ORIENTAL CATFISH *PLOTOSUS LINEATUS*.—The venom apparatus of catfishes is considered to consist of the dorsal and pectoral stings, and the axillary venom glands. According to Reed (1907, Amer. Nat., 41: 553–66; 1924, Zeitschr. Morph. u. Anthro., 24: 227–64), the pectoral spines receive venom from both the pectoral-spine glands and the axillary glands. Although there is some question regarding the exact nature and function of the axillary glands of catfishes, Reed's concept is generally accepted at the present time. It is of considerable significance from the viewpoint of the medical ichthyologist to know whether or not axillary glands are present or absent in a particular species of catfish.

Judging from a recent review of the literature on the venom organs of catfishes, there is considerable confusion regarding the status of the axillary gland of the oriental catfish, *Plotosus lineatus* (Thunberg). (This species has frequently appeared in the literature as *P. anguillaris*, *P. arab*, etc. For a complete review of its synonomy see Smith, 1941, Proc. Biol. Soc. Wash., 54: 15–16). Bottard (1889, Les poissons venimeux, Paris, pp. 80–92) was probably the first to describe the venom apparatus of *P. lineatus*, but his descriptions were limited to the dorsal and pectoral stings. No mention is made of the axillary glands. Since Bottard's descriptions were grossly incomplete, Pawlowsky (1914, Zool. Jahrb., Abth. Anat., 38: 427–42) later redescribed the fin stings and added a complete description and figure of the axillary gland. Reed (1924) merely alluded to the work of Pawlowsky but did not discuss the axillary gland of *Plotosus* in detail. Citterio (1925, Atti Soc. Ital. Sci. Nat., 64: 1–8), in his work on *Ictalurus catus* (Linneaus), stated that "this (axillary) gland is missing in *Plotosus*, according to Bottard and Pawlowsky. This is at least what we gather from the literature." Obviously Citterio had overlooked Pawlowsky's 1914 paper which contained a complete description of the axillary gland. The most recent scientific report on the venom apparatus of *P. lineatus* appears to have been written by Bhimachar (1944, Proc. Indian Acad. Sci., ser. B., 19: 65–70) in which he referred to the axillary gland by stating that "such glands are not present in either *Heteropneustes* or *Plotosus*."

Thanks to the cooperative efforts of Dr. Tokiharu Abe of Tokaiku Suisan Kenkyujo, Tokyo, Japan, we were able to obtain a large collection of freshly frozen specimens of *Plotosus lineatus*. Thirty-five, ranging from 105 mm. to 150 mm. in total length,

were critically examined with the aid of a dissecting microscope. All of them were found to possess an axillary pore. This minute slit-like orifice is ventral to the posthumeral process of the clavicle and slightly superior to the junction of the proximal and middle third of the adducted pectoral spine. Dissection of specimens preserved in formalin revealed the subcutaneous gland to be a glistening white mass, roughly triangular in shape, extending toward the posthumeral process. By injecting India ink into the pore it was readily possible to trace the duct to its origin in the gland. Histological sections showed that the gland was attached to the surrounding structures by adipose and areolar connective tissue. The wall of the gland consists of several layers of fibrous connective tissue. Unfortunately, it is not possible to give a detailed description of the secretory elements, since all of our specimens had undergone degenerative changes as a result of the freezing techniques that were used.

The axillary gland is definitely present in *Plotosus lineatus*. However, the axillary pore, which is the only external evidence of the gland, is easily overlooked by the casual observer. In studying the axillary glands of many of the smaller species of catfishes, it is essential to use a dissecting microscope or a hand lens.

This investigation was supported by a research grant from the National Institutes of Health, Public Health Service, and a contract with the Office of Naval Research, Department of the Navy (Contract No. NONR 205–(00).—Bruce W. Halstead and Robert L. Smith, *School of Tropical and Preventive Medicine, College of Medical Evangelists, Loma Linda, California.*

FIRST RECORD OF THE WHITE PERCH (*MORONE AMERICANA*) IN LAKE ERIE.—On each of the following dates, June 20, July 20, and July 27, 1953, a single white perch, *Morone americana* (Gmelin), was captured in a pound-net which was set in Lake Erie 8.5 miles west of Erie, Pennsylvania. The June 20 specimen, No. 9322 of the Ohio State University collection, is 178 mm. in standard length and 216 mm. in total length; the July 20 specimen is 211 mm. in total length; the July 27 fish was not measured but is approximately of the same length as the others. These fishes were given to me by Mr. Fred Ralph, a commercial fisherman who caught them. On the days when the three specimens were obtained, large numbers of white bass, *Morone chrysops* (Rafinesque), were also taken.

Dr. Milton B. Trautman confirmed my identification of the specimen sent him. Correspondence from Drs. Reeve M. Bailey and Trautman indicates that they are unaware of any records for this species in waters of the Great Lakes above Niagara Falls. Just how and when the white perch was introduced into Lake Erie is unknown.—Alfred Larsen, *Pennsylvania Fish Commission, State Fish Hatchery, Erie, Pennsylvania.*

THE IDENTITY OF THE PARROTFISH *SCARUS AHULA*, THE FEMALE OF *SCARUS PERSPICILLATUS*.—The parrotfishes, *Scarus ahula* Jenkins and *Scarus perspicillatus* Steindachner, are both known only from Johnston Island and the Hawaiian Island area. *Scarus perspicillatus* has a brilliant color pattern of blue and green and yellow, while *Scarus ahula* is red-brown, and aside from a diffuse caudal peduncle band of whitish, without a distinctive color pattern. Fowler (1928, B. P. Bishop Mus. Mem., 10: 372) stated that *S. ahula* differs from *S. perspicillatus* only in its uniform brown coloration. A number of specimens (Table I) of both of these species collected during the course of a reef fishery research program showed that those with the *S. ahula* color pattern were females and those identified as *S. perspicillatus* were males. Certain individuals which seemed to intergrade in their color pattern between *S. ahula* and *S. perspicillatus* proved to be males, the individual nearest *S. ahula* a maturing male.

The typical color pattern of *Scarus perspicillatus*, which in life is most brilliant, is found only in fish approximately 20 cms. in total length and longer (Table I and field observations). It would seem probable, therefore, that the form called *S. perspicillatus* Steindachner is the mature male and that called *S. ahula* the female of a species which should properly be known as *S. perspicillatus* Steindachner, since the description of the male by Steindachner (1879, Denks, Ak. Wiss. Wien, 41: 16) preceded Jenkin's (1899, Bull. U. S. Fish Comm., 19: 61) description of the female by 20 years.

The development of the brilliant color pattern of the mature males is also accompanied by a change in the shape of the rostral profile, which becomes increasingly humped like that of a male *Coryphaena hippurus*; this change also takes place in many other species of adult scarids. The color pattern of the maturing males, as previously mentioned, would seem, in varying degrees to be intermediate between that of *S. ahula* and *S. perspicillatus*. Parrotfish with this intermediate color pattern have been named and figured, as by E. K. Jordan (1925, Proc. U. S. Nat. Mus., 66: 30–31, pl. 2, fig. 1) as *Scarus kraussi. Scarus leucostigma*, described and figured by Jordan, Evermann, and Tanaka (1927, Proc. Calif. Acad. Sci., 16 (20): 676–77, pl. 24, fig. 2), also seems to possess an intermediate color pattern characteristic of maturing males. The figure in color of *Scarus perspicillatus* in Jordan and Snyder (1907, Bull. U. S. Bur. Fish.,

TABLE I

SEX, COLOR PATTERN, MATURITY, AND SIZE FOR TWENTY-FIVE HAWAIIAN PARROTFISHES

Date	Sex	Color pattern*	Maturity	Total length, cm.	Weight in grams
6-19-53	M	*perspicillatus*	Spent	39.6	1500
6-20-53	M	"	...	54.0	3405
9-28-52	M	"	Spent	...	2270
9-28-52	M	"	Spent	...	2724
10-16-52	?	"	Immature	41.3	2724
†	?	"	...	22.0	...
6-20-53	M	*leucostigma-kraussi*	...	41.7	1850
6-22-53	M	"	Ripe	43.5	2270
6-22-53	M	"	Maturing	39.3	1200
9-28-52	F	*ahula*	Spent	...	2270
9-28-52	F	"	Spent	...	2497
9-28-52	F	"	Spent	...	2270
9-28-52	F	"	Spent	...	2270
10-16-52	F	"	Ripe	32.8	1589
10-16-52	F	"	Nearly ripe	36.6	1816
10-16-52	F	"	Spent	40.0	2724
6-20-53	F	"	Maturing	37.2	1175
6-20-53	F	"	Maturing	38.7	1425
6-20-53	F	"	Maturing	39.9	1375
6-20-53	F	"	Maturing	41.0	1550
6-20-53	F	"	Spent	42.5	...
6-20-53	F	"	Spent	42.7	1875
6-20-53	F	"	Spent	43.2	...
6-20-53	F	"	Maturing	43.6	1925
6-20-53	F	"	Spent	44.0	2043

*For color description refer to Jordan and Evermann 1905, Bull. U. S. Fish Comm., 23 (1):347–48 (*perspicillatus*), 351–52 (*ahula*), and reference cited in text (*leucostigma-kraussi*).

† U. S. Nat. Mus. No. 151605.

26 (1906): 216, pl. 13, fig. 1)[1] depicts a young male with the *perspicillatus* color pattern but which has not yet full developed a rostral hump or the chrome yellow color pattern on the pectoral and pelvic fins, as well as on the dorsal and anal, which characterizes the large adult. The types of *Scarus barborus* Jordan and Evermann (1903, Bull. U. S. Fish Comm., 22 (1902): 197–98) from Honolulu were examined by Leonard P. Schultz who wrote that the holotype (USNM No. 50647) is a female and is the same as *S. ahula*.

Sexual dimorphism in color pattern may occur in other species of scarids. Specimens of *Scarus formosus*, with the color patterns illustrated by Jordan and Evermann (1905, Bull. U. S. Fish Comm., 23 (1), pl. 43) for *Scarus lauia*, have for example never been observed by us on specimens smaller than 40 cms. long; in general, the smaller Hawaiian scarids, 20 cms. and less, lack brilliant colors or a distinctive color pattern.

This work was supported, in part, by Federal Aid for Game Fish Restoration, Project F-5-R. Data concerning specimens in the U. S. National Museum (Nos. 50647 and 151605) were supplied by Dr. L. P. Schultz.—VERNON E. BROCK AND YOSHIO YAMAGUCHI, *Division of Fish and Game, Honolulu 1, T. H.*

[1] The names of the two fish figured on plate 13 have been interchanged in the legend and the error is repeated in the citation of the figure in the text.

RECORDS OF FOUR CYPRINID FISHES OF THE GENERA *NOTROPIS* AND *SEMOTILUS* FROM CENTRAL TEXAS.—Many collections have been made during recent years on Lake Travis, one of the several impoundments on the lower Colorado River, just above Austin, Texas. Several of the species taken merit published record because of major extensions in their known ranges. Three species of *Notropis* described recently from Texas by Hubbs and Bonham (1951, Texas Jour. Sci., 3: 91–110), *N. brazosensis*, *N. oxyrhynchus* and *N. potteri*, were recorded as "apparently confined to eastern Texas." They are now recorded for the first time from central Texas. In addition, *Semotilus atromaculatus* (Mitchill) is represented by a single specimen each from Lake Travis and from Lake Granite Shoals, another of the lower Colorado River reservoirs. These two specimens are undoubtedly escaped bait minnows and do not represent established populations.

Notropis brazosensis has been collected only once in Lake Travis, at a point about 6 miles northeast of Spicewood, Burnet County, on March 21, 1952. Due to a prolonged drouth this area of Lake Travis was confined to the original river channel during 1951 and 1952. Since 40 specimens of this shiner were taken in only two seine hauls, it is concluded that the species is now fairly well established in this part of the Colorado River. It is known that bait dealers have been transporting Brazos River minnows in large numbers to the fishing camps on Lake Travis and it is quite likely that this and the other species herein mentioned have been recently introduced as bait. However, there have been no previous collections reported from Lake Travis, and very little collecting has been done throughout the Colorado River drainage. Also, Hubbs and Bonham reported specimens of *N. brazosensis* (taken by A. H. Wright in 1917) from the lower part of the same river. It is therefore possible that this species and the two that follow are native to the upper part of the Colorado River.

Notropis oxyrhynchus is represented by only a single specimen from silty water at the head of a slough in the Hurst Creek area of Lake Travis. It is suspected that other specimens, identified by the author before 1951 as *N. amabilis* (Girard), and since discarded, were also *N. oxyrhynchus*.

Notropis potteri has been seined from three scattered localities on Lake Travis: (1) in the very

clear water near Mansfield Dam, (2) in silty water at the head of Hurst Creek, and (3) in silty water at the head of Big Devil's Canyon. The 16 specimens taken indicate that a population of this species may now be established in Lake Travis. All three species of *Notropis* were taken in 1953 in the Colorado River near Austin, according to word from Clark Hubbs.—KENNETH C. JURGENS, *Division of Inland Fisheries, Texas Game and Fish Commission, Austin, Texas.*

Herpetological Notes

OBSERVATIONS ON AUTUMN MOVEMENTS OF THE SALAMANDER *AMBYSTOMA TIGRINUM TIGRINUM* IN SOUTHEASTERN MICHIGAN.—Three species of *Ambystoma* are commonly found in southeastern Michigan; these are *A. jeffersonianum* (Green), *A. maculatum* (Shaw), and *A. t. tigrinum* (Green). *A. jeffersonianum* and *A. maculatum* are more closely restricted to woodland areas than is *A. t. tigrinum*, which is often found in open fields and brushy areas. Of the three forms, *A. t. tigrinum* is the least common at the breeding pools in the spring, and in general it does not appear to be as abundant as the other two forms. Therefore, it was with some surprise that a large concentration of these salamanders was encountered in the autumn of 1952.

After a heavy rain during the night, Mrs. Vera Dupree of East Ann Arbor presented to the Museum of Zoology seven specimens of *Ambystoma t. tigrinum* that she had found the following morning (October 14, 1952) on the highway north of the village of Whitmore Lake, Livingston County, Michigan. She said that there were numerous dead specimens on the road. The same afternoon Normal E. Hartweg, Paul S. Martin, and I located the area where the specimens had been found. This is a section of a main highway (US 23) from 4.5 to 6.7 miles north of the village of Whitmore Lake. We carefully examined the road and shoulders and found 99 dead individuals. One of these was killed by passing traffic while we walked along the road. All of the dead salamanders were removed from the road, so that no individual would be counted more than once. In the midst of a heavy rain the same evening Hartweg and I again visited the area, driving the 2.2-mile section of road several times. We found 32 live and 27 dead individuals on the road. Of the live individuals, 19 were crawling west on the road and 13 were crawling east. The air temperature in the afternoon had reached 57°F., but had dropped to 48° in the evening.

On the morning of October 15 Martin revisited the area and found 2 live and 15 dead specimens on the road. The same afternoon we again worked the area, finding 87 dead and 5 live individuals in the 2.2-mile section of the road, 34 dead within a distance of 1.9 miles to the south, and 3 dead within a distance of 0.2 mile to the north. The air temperature during the afternoon reached 52° F. By 8:45 PM the temperature had dropped to 41° and no additional salamanders were found. Thus, in a period of 30 hours, 274 individuals of *Ambystoma t. tigrinum* were found on a 2.2 mile section of the road. Of this number only 46 were found alive, giving an indication of the death toll due to automobiles. Also, 37 individuals were found beyond the limits of the intensely worked area.

The area was revisited several times during the next few days, but unfavorable weather must have restricted the movements of the salamanders. However, a month later, following a rain on the morning of November 17, 2 live and 19 dead individuals were found in the same area. A subsequent search the same evening revealed no specimens. The last individual of the season was found by a farmer in the area. This specimen was found in the open during the day on November 20.

The area in which this concentration of salamanders was found consists of slightly rolling hills bearing very few trees. For the most part the land is devoted to pasture or is overgrown with brush. There are no patches of woodlands in the immediate vicinity. Just south of the north border of the area are two small ponds on either side of the road. Investigation of these ponds showed no evidence of amphibian life.

Of the specimens that were collected alive and are available for study, 18 are females, 14 are males, and 13 are immature. The males average 93.1 mm. in body length, the females 93.3, and the immatures 78.3. The females contain well developed eggs, and the cloacal glands of the males are swollen. When the salamanders were brought into the laboratory and placed in aquaria they showed no desire to breed. Of the six specimens examined for stomach contents, three were empty, two contained the remains of crickets, and one contained a partially digested beetle larva.

The farmers in the area are well acquainted with this salamander, having often found them in their barns and cellars. However, they said that they had never known them to be so abundant as they

were when we found the large concentration. Breckenridge (1944, Reptiles and Amphibians of Minnesota: 51) stated that *Ambystoma t. tigrinum* moves on wet or foggy nights in the fall in search of hibernating quarters. Other workers have offered the same explanation for the fall movements. The salamanders found in southeastern Michigan appeared to be moving randomly; there did not appear to be a definite migration in any one direction. Therefore, I can offer no other explanation except that after spending several months in aestivation the salamanders become active during the autumn rains and do not necessarily leave the summer retreats to search for hibernation quarters.

The only other salamander found at the time of the movement of the *Ambystoma t. tigrinum* was one small *Ambystoma jeffersonianum*. It was found dead on the road in a wooded region south of the area where the *A. t. tigrinum* were found. Investigations of areas where *Ambystoma jeffersonianum* and *A. maculatum* are commonly found in the spring met with negative results. Several species of frogs, including *Acris crepitans*, *Rana catesbeiana*, *R. clamitans*, *R. palustris*, and *R. pipiens*, were found alone with the *Ambystoma t. tigrinum*. One juvenile *Coluber constrictor flaviventris* was also found, dead.

I wish to take this opportunity to thank Norman E. Hartweg, William W. Hassler, Paul S. Martin, Owen J. Sexton, and Thomas M. Uzzell, Jr., for their assistance in the field.—William E. Duellman, *Museum of Zoology, Univeristy of Michigan, Ann Arbor, Michigan.*

ANOTHER NOTEWORTHY RANGE EXTENSION OF THE TOAD *BUFO PUNCTATUS* IN TEXAS.—The eastern limits of *Bufo punctatus* Baird and Girard in Texas were designated by Brown (1950, Baylor Univ. Studies: 48) as roughly following a line extending through Maverick, Bexar, Travis, McLennan, and Tarrant counties, i.e., generally limited by the Balcones Escarpment. In presenting additional data on Texan species, Smith and Sanders (1952, Texas Jour. Sci., 4: 206) recorded the capture of one *B. punctatus* (Sanders' collection No. 1059) from Dallas County. As explained by the authors of the latter publication, the Dallas County record extended the known eastern range of the species about 35 miles. However, the range of this toad was given by Wright and Wright (1938, Trans. Texas Acad. Sci., 21: 18) to be "Dallas to Waco, San Antonio, San Diego, Brownsville, and westward."

A still farther eastern record is now at hand. The junior author collected a male (Baldauf collection No. 600) on old Highway No. 6, three miles south of College Station, Brazos County, Texas on the night of April 28, 1953 following a rain. The specimen has a snout-vent length of 70.0 mm. The Brazos County record extends the range of the species in Texas approximately 40 miles to the east.

Desert canyons, rocky semiarid areas, mountains, and dissected plateaus have been listed as the habitat of this bufonid. Since the Brazos County specimen (and that of Dallas County) is somewhat out of the usual habitat, it is noteworth to record the capture.—Richard J. Baldauf and Rexford D. Lord, Jr., *Department of Biology, Agricultural and Mechanical College of Texas, College Station, Texas.*

THE BARKING FROG, *HYLA GRATIOSA*, IN THE CUMBERLAND PLATEAU OF GEORGIA.—The barking frog is found in the Atlantic and Gulf Coastal Plain Region from Virginia to Florida to Louisiana (Wright and Wright, 1949, Handbook of Frogs and Toads). The only published record of its occurrence out of the Coastal Plain is that of Cahn (1939, Copeia (1): 52–3) who captured several specimens near Hartselle, Alabama, located in the Piedmont Plateau in the north central part of the state.

On May 12, 1953, an adult male barking frog was collected in the northwestern part of Georgia. It was taken in a natural permanent pond near Trenton, Dade County, by Wilbur Duncan. Judging from this captured specimen the population there does not appear to be genetically distinct from that of the Coastal Plain. In general body proportions and coloration it conforms to the description given by Wright and Wright (*op. cit.*) for *Hyla gratiosa*. This discovery greatly extends the known range for the species but it is more important because the site where the frog was found is about 125 miles from the Fall Line and is in the Cumberland Plateau Province at an elevation of 1920 feet above sea level.—Bernard Martof, *Department of Zoology, University of Georgia, Athens, Georgia.*

LOGGERHEAD TURTLES, *CARETTA CARETTA CARETTA*, FROM NORTH CAROLINA.—On March 10, 1953 the trawler Adele captained by Mr. Jim Beebe of Islip, Long Island, captured a large male loggerhead turtle, *Caretta c. caretta* (Linné), several miles southeast of Cape Lookout, North Carolina (approximately 34° 27′ N, 76° 18′ W). Through the courtesy of Mr. Ottis Purifoy, a fish dealer of Morehead City, North Carolina, the writer was notified of this event.

Carr (1952, Handbook of Turtles) stated that large male loggerheads are rarely captured and authentic records for such are desirable. On commercial weighing scales the specimen weighed 400.5 pounds. The following dimensions to the nearest half-inch were taken from the living specimen by means of a yard stick and a block of wood: total

TABLE I

WEIGHTS AND MEASUREMENTS OF SEVEN FEMALES OF *Caretta c. caretta* COLLECTED OFF CAPE LOOKOUT, NORTH CAROLINA, MARCH 20, 1953

Measurements in inches, weight in pounds

Weight	Total length	Carapace		Plastron, length	Maximum head width
		Length	Width		
94	36.0	26.5	22.5	20.0	5.0
105	36.5	26.0	22.0	20.0	5.5
109	39.0	26.5	22.0	20.5	6.0
123	39.5	28.5	22.0	21.5	6.5
125	38.5	28.0	23.0	22.0	6.5
140	38.0	28.5	23.5	21.5	6.0
155	41.0	29.5	25.5	23.0	6.0

length (tip of beak to tip of tail), 70 inches; length of carapace, 41 inches; width of carapace, 29.5 inches; length of plastron, 32.5 inches; greatest width of head, 8.5 inches; length of tail extending beyond posterior margin of carapace, 17 inches.

On March 20, 1953 seven female loggerheads were captured in the same area as the large male described above. Measurements were taken in the same manner described above (Table I). In none of the females did the tail extend beyond the posterior margin of the carapace.

Acknowledgment is hereby made for the cheerful assistance of Mr. Jim Beebe, Jr., of Islip, Long Island, in the weighing of the turtles.—WILLIAM E. FAHY, *Institute of Fisheries Research, University of North Carolina, Morehead City, North Carolina.*

THE NARROW-MOUTHED TOADS *MICROHYLA OLIVACEA* AND *M. CAROLINENSIS* IN NORTHEASTERN OKLAHOMA.—A. P. Blair reported (1950, COPEIA (2): 152, and 1952, COPEIA (2): 114), on good evidence, that *Microhyla olivacea* and *Microhyla carolinensis* behave as distinct species in northeastern Oklahoma. On June 6, 1952, after a thunder shower, I observed both of the above species calling in the same pond along a roadside 15 miles south of Tahlequah, Cherokee County, Oklahoma. Samples of both species were collected. Four clasping pairs of *M. carolinensis* were observed, and many eggs were floating on the water in loose clusters of from 15 to 20. No clasping pairs of *M. olivacea* were found.

The calls of these two species were so different that the author knew which one to expect to find while stalking them. There were approximately 20 males of *carolinensis* calling in this quarter-acre pond and about half that number of *olivacea*. Perhaps the *olivacea* had passed their breeding peak for the spring.

Also calling at the same time were a few individuals of *Pseudacris nigrita* and *Hyla versicolor*. It may be that *M. carolinensis* and *M. olivacea* hybridize or intergrade in some localities, but certainly they act as distinct species in this part of northeastern Oklahoma.—HAGUE L. LINDSAY, JR., *Department of Zoology, University of Texas, Austin, Texas.*

FOSSIL RATTLESNAKES OF THE GENUS *CROTALUS* FROM NORTHERN MASSACHUSETTS.—Several years ago Mr. Robert Sanders, an undergraduate student at the University of Connecticut, brought to our attention several hundred fossil crotalid vertebrae and ribs collected by him and his brother. In early spring, 1951, Mr. Sanders, the authors, and several others, revisited the locality. They collected many more vertebrae and ribs as well as numerous other skeletal elements, and fossil remains of mammals and snails. The fossils were found in a public park east of Greenfield, Franklin County, Massachusetts, beyond the end of Highland Avenue. They lay in several basal fissures and in talus, beneath a basaltic palisade. The deposit probably represents the deepest end of a former hibernation den, the rest of which has been lost through erosion of the cliff. Although the exact age of the deposit has not been determined, the associated remains indicate a late Pleistocene or sub-Recent age. The fossils were found disarticulated and thoroughly mixed up, and show no indication of ever having been laid in strata. They are not evidently mineralized, although a lime drip has encrusted and conglomerated a few.

The rattlesnake remains (Amer. Mus. Nat. Hist., Dept. Geol. and Paleont. No. 7520) consist of the following (including both complete and incomplete bones): premaxillae, maxillae with and without fangs, isolated fangs, palatines, ectopterygoids, pterygoids, basicrania, prefrontals, frontals, parietals, postfrontal spines, quadrates, squamosals, dentaries, proximal halves of the lower jaw (articular, angular, and surangular), at least a thousand vertebrae from all regions of the body (except the atlas and axis), styles (shakers), and a few hundred ribs. These are apparently the remains of fifteen to twenty fairly large specimens of *Crotalus*, indistinguishable as far as we can determine from *C. horridus*. This opinion was corroborated by Mr. B. Brattstrom, to whom (through Dr. L. M. Klauber) we had sent a sample of the collection.

In the fossils (seemingly consistently) the posterior angle between the hypapophysis and the horizontal axis is greater than in the Recent *C. horridus* that we have seen, but the same large inclination is present in available specimens of *C. adamanteus*. Brattstrom, however, finds that some *C. horridus* have the hypapophyses angled as

in the fossils. We agree with him that this character is probably not of taxonomic importance, but is one of individual variation.

Klauber and Brattstrom have estimated that a fang 9.0 mm. long (measured from the proximal aperture of the lumen to the tip) represents an individual with a body length of about 960 mm. Longer fangs are present in the collection, and when compared with Klauber's (1935, Occas. Papers San Diego Natural History Society: 46) graph give an estimated body length of 1,100 mm. The length of the individuals of our sample probably ranged from 900 to 1,300 mm. There seem to be no really young rattlesnakes in this collection. This may be due to the smaller individuals not being well ossified, and therefore not preserved; or to their remaining in other portions of the den. Gloyd (1940, Chicago Academy of Science, special number: 172, 187) recorded the maximum length of *C. h. horridus* as 1,297 mm., and of *C. h. atricaudatus* as 1,665 mm. Thus the largest individuals in our sample are about the maximum for *C. h. horridus*, and are well within the range of *C. h. atricaudatus*.

The snake remains are represented by an abundance of some parts, and a scarcity of others. There is a complete absence of bones from the occipital region, and no atlas or axis vertebrae. The relative rarity of the premaxilla and the quadrate may be due to their slight structure. In recent *Crotalus* the thoracic vertebrae can be divided into two intergrading groups, the anterior and posterior thoracics. The anterior group is characterized by the greater height of the neural spine, and the relative shortness of the hypapophysis. Both groups are composed of about equal numbers of vertebrae. In the fossil remains over three-quarters of all the vertebrae can be classified as posterior thoracics, the remainder being cervicals, anterior thoracics, and caudals.

Associated with the rattlesnake remains were scattered elements of *Procyon lotor*, *Pitimys pinetorum*, *Blarina brevicauda*, *Sorex* sp., *Peromyscus* sp., *Synaptomys cooperi*, and *Tamias striatus*. All the above mammals are still found in the region of the deposit. The above identifications were made by Dr. R. Wetzel of the University of Connecticut and Dr. K. F. Koopman of Queens College.

Also present are numerous pulmonate snail shells, distributed throughout the deposit exactly as the other fossils. Dr. Horace G. Richards of the Academy of Natural Sciences of Philadelphia has kindly identified the shells as follows: *Triodopsis albolabris* (Say), *T. tridentata* (Say), and *Anguispira alternata* (Say). All three species are still living in the New England region.

In conclusion, we feel that the rattlesnake is probably a *Crotalus horridus*. The apparent discrepancies noted above, however, cannot be properly evaluated because of a lack of comparative material of the postcranial skeleton.—RICHARD VAN FRANK, *Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts*, AND MAX K. HECHT, *Department of Geology and Paleontology, American Museum of Natural History New York City, New York.*

REVIEWS AND COMMENTS

VOICES OF THE NIGHT. Produced by Peter Paul Kellogg and Arthur A. Allen for the Albert R. Brand Bird Song Foundation, 1953. Cornell University Records. Twelve-inch Vinylite LP, 33⅓ RPM. $6.75. Professors Kellogg and Allen are to be congratulated upon the appearance of this new edition of "Voices of the Night." The twenty-six frogs and toads included in the earlier (1948) album are heard in this single record with the addition of the following eight forms: *Hyla femoralis, Hyla septentrionalis, Microhyla carolinensis, Eleutherodactylus ricordi, Bufo americanus copei, Bufo cognatus, Rana capito* and *Rano grylio*. This is not simply the old album with additions, however, since several of the species have been recorded anew and there has been some rearrangement of the order. In general, closely related forms are heard consecutively. The place and time of each recording is given.

This record does three things. It provides an introduction to one aspect of the out-of-doors for naturalists in general; it furnishes an additional tool for the teaching of herpetology; and it makes available in permanent form some specific and subspecific characters of frogs and toads that cannot be embodied in a bottle of alcohol. The recordings are excellent both in the reproduction of single voices and in that the calls are heard against a back-

ground of natural sounds. As Dr. Schmidt has earlier suggested, a chair-bound biologist may spend a happy evening by turning out the light and playing this record through. The chorus of *Scaphiopus* or the calling of the peepers can easily carry one back to collecting jaunts long since past. To this reviewer, not only do the calls of the frogs themselves invoke memories of pleasant collecting trips, but the voice of Dr. Allen as he introduces each form brings into sharp focus enjoyable evenings spent in the swamps with him and Dr. Kellogg. It must be admitted, however, that some moments are pleasant chiefly in retrospect. There was the night 'Doc' and I stood knee-deep in a small pool waiting for a *femoralis* to call, with the mosquitoes so thick about our heads that their hungry buzzing was picked up by the recorder back in the car.

Careful editing of the material on the record has been accompanied by an artistic touch. The waning ardor of the bullfrog makes a basso-profundo aria that will be played and replayed.

Adverse comments are few. I regret that the recording of *Bufo quercicus* does not give a true impression of the terrific din made by a chorus of these tiny toads, and it seems to me that the non-breeding call of *Hyla squirella* would sound more natural if the *apparent* distance of the call were a little greater.

It is to be hoped that these two ornithologists will continue to make such worthwhile contributions to herpetology.—COLEMAN J. GOIN, *Department of Biology, University of Florida, Gainesville, Florida.*

HISTORICAL ASPECTS OF ORGANIC EVOLUTION. By Philip G. Fothergill. Philosophical Library, New York, 1951: xvii + 427. $6.00.—Here is a book that meets a very definite need in the biologist's library both for reading and for reference. The reading will be a pleasure for the book is both well written and well organized. For reference it has an extended and well-analysed table of contents, a detailed index of topics and persons quoted or referred to, and a bibliography of some 29 pages.

Professor Hislop Harrison in his foreword writes that the author had three special objectives: "(1) to fill the gaps in the literature in respect to the history of the subject and to bring this aspect up to date, (2) to present it in such a manner as to enable both the general and the specialist reader to evaluate the conflicting meanings of the word 'evolution', (3) by presenting an unbiased account of the subject of evolution to show that even a person believing in a clear-cut religion can also believe in and deal with the subject of evolution without prejudice to his religious beliefs."

To take up the rather unexpected third objective first, Professor Fothergill has written in part as a Roman Catholic apologist for evolution, to other Catholics who may have, he feels, a philosophical anti-evolutionary prejudice. This has in no way weakened or biased this very excellent account of the development of the modern concept of evolution. The author has succeeded in clearly distinguishing between his treatment of scientific concepts and evidence as a biologist and his understanding as a catholic of some of the philosophical or religious dogmas that might be interpreted as in conflict with evolution. I am not a catholic, but I found these brief digressions or asides of definite interest and feel indeed that they have pertinence in a history of evolution, if only as a reminder that the long conflict between evolutionary concepts and fundamentalist theology still exists.

The first objective—to fill the gaps in the history of evolution and bring it up to date—is most adequately done. The book is almost equally divided between "Part I. The Historical Development of the Idea of Organic Evolution" and "Part II. Cytogenetics and the Modern Causal Theories of Organic Evolution." with eight brief appendices: "Aristotle's Theory of Matter and Form." "Aristotle's Classification of Animals." "A synopsis of Lamarck's Classification of Animals," "Some Further Lamarckian Experiments," "A Synopsis of, and Reference to, Earlier Experiments Demonstrating the Occurrence of Natural Selection," and three examples of genetic methods or experiments.

Part I is further subdivided. A brief "Early Period" is concerned chiefly with Aristotle and the Aristotelian synthesis of biology. A somewhat longer chapter on the "Speculative Period" examines the contributions toward evolution of Linnaeus, Buffon and other naturalists, touches briefly on the speculations of Oken and Diderot, and concludes with the natural philosophers leading up to and including Kant.

The "Formulative Period" which concludes Part I extends from Erasamus Darwin to 1900. Here two chapters are given to a clear and concise account of the three quarters of a century of evolutionary thought that preceded Charles Darwin, a chapter to Darwin and Darwinism and a fourth chapter, entitled, "After Darwin" includes Neo-Darwinism and Neo-Lamarckism, an account of Wallace and "Theories supplementary to Natural Selection", and "Theories replacing Natural Selection." The statement and assessment of the contributions of Cuvier and Richard Owen, though brief, are especially good—and concerned with their contributions and ideas rather than with parts they played in the controversies of their time.

Part II is a concise but well-organized account of the development of evolutionary thought between 1900 and about 1940. Two chapters on Mendelism and the development of cytogenetics stress their

relevance to evolutionary theory and give a good perspective of historical sequence. The two final chapters are given to "Modern Causal Theories of Evolution and Modern Neo-Darwinism: Mutations and Selection." Here the treatment is much more selective and one is impressed by the omission of any consideration of ecological or biogeographic contributions except for Willis' Age and Area. What is given, however, is well done and provides a rapid survey of a number of important concepts that have directly or indirectly contributed to our present day concept of evolutionary processes.

In some ways this book recalls Kellogg's *Darwinism Today*, written in 1907. At once broader and much less detailed than Kellogg, it has the advantage of 45 years of retrospect for evaluation and selection. Fothergill is also writing to a wider and less professional group of readers—but like Kellogg he is concerned with ideas rather than people. There are no biographical data whatever but the simple, clear presentation of their ideas will do much to give reality to a long list of earlier workers who contributed to the evolving concept of organic evolution.—J. SPEED ROGERS, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

DIE FISCHDRESSUREN UND IHRE SINNESPHYSIOLOGISCHEN GRUNDLAGEN. By Konrad Herter. Akademie Verlag, Berlin, 1953: vi + 326, 147 figs. $7.68 U. S.—A scholarly treatment of sensory physiology of fishes, in addition to the methods and results of training fishes to sensory stimuli, is summarized from 254 references taken principally from the European literature in German.

An introductory chapter sketches the sensory aspects of the environment and the general behavioral phenomena described earlier by Lorenz and Tinbergen. Selected features of interest: Defense of a specific territory by *Hemigrammus* is reminiscent of the work in the Allee school in this country. New to me was the report that *Cottus gobio* possesses "Regional Memory" and can find its way to its nest by some obscure sensory mechanism after being displaced 50 meters from its nest.

Herter reviews the literature in sensory physiology and anatomy of sense organs which has not been summarized so fully since Wunder's book in 1936. His section of vision, the area of concentration in his own laboratory, is unusually good. I was again interested in a review of studies by Wunder on the histological basis for "twilight" and "bright light" fishes: the former have 39–263 and the latter 4–18 visual cells (rods and cones) per unit area of the retina (range of 5 species each). Herter critically points out the difference in behavior to light of the Gründling of different ages. Because he worked with young fishes, Wunder apparently classified this species as a "bright light" fish, but Möhres' studies on adults show it to prefer darkness.

Recently I reviewed the field on olfaction and taste in fishes, and consequently was familiar with the citations Herter abstracted. I was surprised, however, that he did not have access to postwar (II) American and English literature. He was unaware of Bull's recent work in England, of Hoar's studies on light and current reactions of young salmon, of Fry's study on temperature adaptation or of the work in my laboratory on sense of smell published since 1948. Residing in eastern Germany he may have been restricted to older journals in English.

One is impressed with the many ingenious experimental innovations developed over the years in training fishes with the conditioned reflex technique as applied to the aquatic medium. Moreover, one is amazed at the unbelievable sensory accomplishments and abilities of fishes and the large number of studies that have been done.

The 169 pages devoted to spontaneous responses, conditioned responses, and training techniques are replete with descriptive detail, generous illustrations and tables. There are more typographical errors than one sees in most German books. Many new data are presented from Herter's own laboratory.

Since fishes cannot talk, conditioned response tests are an important tool for determining the sensitivity of an organ or for inquiring into meaning of a stimulus to a fish. I recommend this book to every student who undertakes a study of fish behavior and to all who want a grasp of sensory physiology. Although fish can't talk, I was amused at Herter's experiment on sound detection. He was successful in getting two fish in the same aquarium to come to food when its name was called, Adam for one and Eva the other. They discriminated names after three days training over 30 trials. The important sound for the fish was the vowel in each word.

A brief, critical chapter on the psychology of training concludes the volume. It points up various aspects of learning, displacement behavior, effective stimuli, retention, and individual and group performance.—ARTHUR D. HASLER, *Department of Zoology The University of Wisconsin, Madison 6, Wisconsin.*

BIBLIOGRAPHY OF THE NOISES MADE BY MARINE ORGANISMS. By W. N. Kellogg. Amer. Mus. Novitates, No. 1611: 1–5; 1953.—Underwater sounds and sonic scattering layers have recently become fields of interest and practical significance to both ichthyologists and fishery biologists. Researches in these fields have increased in near geometric progression since World War II. The author, hampered by the lack of a beginning

source of information on the subject, prepared the cited list. Kellogg disarms any critic by stating his work "... can hardly claim to be exhaustive, ..."; it is not, and considerably more information can be had on fish sound production alone than is suggested by Kellogg's total compilation of 53 titles. Unfortunately his list, which includes some declassified government reports, fails to record a much more complete bibliography on fish noises which was contained in a report (unclassified) issued by the Woods Hole Oceanographic Institution (Fish, 1948. Sonic Fishes of the Pacific. *Pac. Ocean. Biol. Project., Tech. Report* No. 2: 1–144, W. H. O. I.). As an aid to scientific workers, the Library of Congress in conjunction with the Department of Defense lists titles of current research reports in the *Title Announcement Bulletin* (TAB), and formerly in the *Technical Information Pilot* (TIP). Although unavailable to individuals, many librairies receive these publications, which provide source information on government-sponsored research on underwater sound as well as on biology, physiology, etc.—NORMAN J. WILIMOVSKY, *Natural History Museum, Stanford University, California.*

FISHES FOUND IN THE FRESHWATERS OF TEXAS. By Frank T. Knapp. Ragland Studio and Litho Printing Co., Brunswick, Georgia, 1953: viii + 166, 190 figs. $2.00 prepaid.—Despite an actively growing body of data on North American freshwater fishes, its translation into reliable manuals for fishery workers, students, sportsmen, and other interested persons has been distressingly slow and, commonly, inadequate. As a measure of improvement, for several northern and western states or regions there are now available popular or semi-technical handbooks providing adequate means for fish identification, distribution, and summary statements on habits and habitat. Others are in preparation. Probably the greatest need exists in the southern states, for most of which area Jordan and Evermann's half-century-old classic is still the only usable work. A book on Texas freshwater fishes meets a genuine need.

Following introductory paragraphs on the history of Texas ichthyology, classification of fishes, and distribution of Texas freshwater fishes, Knapp's book gets quickly to its avowed purpose—to provide a means for accurate identification of the fishes found in the fresh waters of Texas. A chapter on counts, measurements, and terminology is followed by an illustrated key to orders; further keys to families and to species are distributed through the text. Each family is introduced by a comprehensive statement covering its characters, composition, importance, and interesting attributes. The keys are of the commonly employed dichotomous, couplet type. A brief text account for each species gives common and scientific names, general geographic range, and, usually, its occurrence and habitat in Texas. A profusion of sketches and outline drawings that emphasize characters used in the keys furnish welcome visual assists in making determinations. The generic nomenclature employed follows the recent trend toward conservatism; with few exceptions the specific names are strictly up-to-date.

The taxonomic ichthyologist will note in this handbook an unnecessarily large number of errors. It is regrettable that many of these will be equally apparent, or cause confusion, to the inexperienced reader. There are many misspelled names and other words. More serious, however, are the not infrequent contradictions in the keys that make it impossible to key some species properly. An especially troublesome slip appears in item nine of the key to orders wherein undue weight is placed on the position of the pelvic (termed ventral) fins with the result that a needlefish would key out to the Cypriniformes! If, prior to publication, authors would take an example of each species and run it point-by-point through their own keys, subsequent users would find the product more readily workable. (I hope this reviewer remembers to follow his own advice when next he writes a key.)

For the most part the general range statements are adequate and for some species are the best available, but there are a few major slips, such as the failure to include the area from Massachusetts Bay to east Florida in the range of *Menidia beryllina*. In my opinion it would have been preferable to eliminate authorities names following scientific names where they appear in keys, under illustrations, and casually in the text, retaining them only in the primary text entries. In bringing adjectival specific names into agreement with changed generic names a few errors have been made and some substantives have been modified improperly: *Dorosoma petenense*, *Megalops atlantica*, *Bagre marinus*, *Etheostoma fonticola*, and *Cichlasoma cyanoguttatum* should be spelled as here written. Several species not known to occur in Texas fresh waters are included.

Careful perusal of this first edition reveals multiple unfortunate results of hasty preparation: the line drawings are poorly executed, the keys suffer from lack of proper checking and attention to accuracy, grammatical errors are frequent, and the composition and proofing are careless. The work of a competent and exacting editor would have changed most of this. If in addition a late draft of the manuscript had been read by one or more colleagues, a majority of the bothersome technical slips could have been eliminated, and the result would have been thoroughly workmanlike as well as a useful tool. As it is this book is the best modern work on fishes of the southwestern states. The author has labored in a morass of unorganized literature, and

many of the data have been culled from still unpublished work. It is perhaps surprising that Mr. Knapp has been so successful in this preliminary effort, which should prove an invaluable work in subsequent editions.—REEVE M. BAILEY, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

THE FRESH-WATER FISHES OF BRITISH COLUMBIA. By G. Clifford Carl and W. A. Clemens. British Columbia Prov. Mus., Handbook No. 5, ed. 2, 1953: 136 pp., 7 col. pls. (trout), and numerous black and white illustrations. $0.50.—The first edition of this handy booklet (reviewed in COPEIA, 1949 (1): 82), recently exhausted, has been expanded by changes in range statements, the addition of two cyprinids (*Hybognathus hankinsoni* and *Acrocheilus alutaceum*), both illustrated, some revision in the keys (e. g., in the Cottidae), and additions of recent literature. The type is larger and hence more readable. All of these changes add only four pages to its length. The handbook is well worth its reasonable price.—ROBERT RUSH MILLER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

CULTURE AND DISEASES OF GAME FISHES. By H. S. Davis. Univ. of California Press, Berkeley and Los Angeles, 1953: x + 332, figs. 1–55. $5.00.—This is a long-overdue book by the dean of American workers on fish diseases. The book consists of two parts: Pt. One (178 pages) dealing with the culture of game fishes, and Pt. Two (118 pages) dealing with parasites and diseases of fishes and their control. Appendixes, bibliography and index occupy 36 pages. The part on culture contains chapters on: the history of fish culture; location and construction of trout hatcheries; propagation, care and rearing of trout; trout feeding; propagation of salmons, grayling, pike etc.; construction of fish ponds; propagation of bass, catfish, minnows and suckers; and the farm fishpond. The part on parasites and diseases has chapters on general control of external and internal parasites; discussions of life history and control, by individual species, of external and internal animal parasites; a similar treatment of bacterial diseases; and a discussion of miscellaneous diseases including fungus and disorders of dietary and physiological origin. The appendixes cover a few items including a fish-egg incubator, an egg-picker, culture of daphnia, etc. The bibliography contains about 300 titles, largely of American literature prior to 1951.

The book is highly factual as a result of an extensive review of the literature, and the discussion of fish-cultural practices is written in an authoritative style, and justly so, in view of the long experience of the author in this field.

Typographically the book is a fine job, although the margin alignment of the bibliography could be improved (in a subsequent edition). The subject matter would lend itself to a more generous use of illustrations. The binding is excellent.

Davis' book is a "must" for fish-culturists, and it will be very useful also to fisheries administrators and biologists, as well as informative to sportsmen. —GERALD P. COOPER, *Institute for Fisheries Research, University Museums Annex, Ann Arbor, Michigan.*

THE BLACK RIVER STUDIES. By John L. Funk, et al. The Univ. of Missouri Studies, 26 (2), 1953: 1–136. $2.50.—The report consists of a series of seven papers prepared by Mr. Funk and five collaborators, on a study of the limnology and fishes of a Missouri Ozark river both before and after the construction of a 1650-acre impoundment (Clearwater Lake) on the river. The separate papers deal with (1) a description of the river basin, (2) benthos of the river and lake, (3) small fishes of the river and lake, (4) large fishes, (5) age and growth of the smallmouth bass, rock bass, longear sunfish, gizzard shad, and green sunfish, (6) management and utilization of the fishery, and (7) appraisal of the fishery.

EDITORIAL NOTES AND NEWS

ALFRED CLEVELAND WEED

1881 – 1953

MR. ALFRED C. WEED, retired Curator of Fishes at the Chicago Natural History Museum, died on November 30, 1953, at the age of 72. He had served as a staff member since January, 1921. His principal effort during the 21 years that he was in charge of the Division of Fishes was directed toward adding to the study collections and improving the exhibits. This latter work produced the habitat groups and systematic series in the Hall of Fishes that was

opened in July, 1941, two years before he was forced to retire because of poor health.

Most of his research papers comprised notes on field observations and short taxonomic revisions of groups of fishes with which he came in contact during field work for exhibit purposes. Research was consequently only secondary, accomplished during the brief intervals between expeditions, local field work and the tasks of curating the collections and improving the exhibits. The following bibliography was prepared by LOREN P. WOODS.

BIBLIOGRAPHY OF A. C. WEED

Before 1927. Many short notes and articles in The Rural New-Yorker, and other magazines and newspapers.

1909. (With Barton A. Bean as senior author.) Description of a new skate (*Dactylobatus armatus*) from deep water off the southern Atlantic Coast of the United States. *Proc. U. S. Nat. Mus., 36: 459–61, pl. 38.*

1909. (With Barton A. Bean as senior author.) Descriptions of two new species of electric rays, of the family Narcobatidae, from deep water off the southern Atlantic Coast of the United States. *Ibid., 36: 677–80.*

1909. (With Barton A. Bean as senior author.) Notes on certain features of the life history of the Alaskan freshwater sculpin. *Smithsonian Misc. Coll., 52. pt. 4: 457–60.*

1910. (With Barton A. Bean as senior author.) Notes on *Anteliochimaera* and related genera of chimaeroid fishes. *Proc. U. S. Nat. Mus. 37: 661–3, pls. 38–9.*

1910. (With Barton A. Bean as senior author.) A review of the venomous toadfishes. *Ibid., 38: 511–26, pls. 31–4.*

1911. (With Barton A. Bean as senior author.) Notes on the coloration of fishes. *Proc. Biol. Soc. Washington, 24: 69–76.*

1911. (With Barton A. Bean as senior author.) An electric ray and its young from the west coast of Florida. *Proc. U. S. Nat. Mus., 40: 231–2, pls. 10–1.*

1911. (With Barton A. Bean as senior author.) Recent additions to the fish fauna of the District of Columbia. *Proc. Biol. Soc. Washington, 24: 171–4.*

1911. (With Barton A. Bean as senior author.) Notes on the genus *Lepomis. Proc. U. S. Nat. Mus., 40: 369–76, pls. 42–50.*

1912. (With Barton A. Bean as senior author.) Notes on a collection of fishes from Java, made by Owen Bryant and William Palmerin 1909, with description of a new species. *Ibid., 42: 587–611, pls. 73–5.*

1915. (With W. L. McAtee as senior author.) First list of the fishes of the vicinity of Plummer's Island, Maryland. *Proc. Biol. Soc. Washington, 28: 1–14, pls. 1–2.*

1920. (With Barton A. Bean as senior author.) Notes on a collection of fishes from Vancouver Island, B. C. *Trans. Royal Soc. Canada, ser. 3, vol. 13: 69–83, pls. 1–4.*

1921. Fishes from southern Wisconsin. COPEIA, *No. 99: 69–72.*

1922. New frogs from Minnesota. *Proc. Biol. Soc. Washington, 35: 107–10.*

1922. Reptile notes. COPEIA, *No. 112: 84–7.*

1923. Distribution of the pickerels. COPEIA, *No. 115: 21–3.*

1923. Notes on reptiles and batrachians of central Illinois. COPEIA, *No. 116: 45–50.*

1923. The Alligator Gar. *Field Mus. Nat. Hist., Zool. Leaflet No. 5: 57–72, 1 pl.*

1925. Some pickerel names. COPEIA, *No. 144: 49–51.*

1925. Feeding the paddlefish. COPEIA, *No. 146: 67–8.*

1925. Feeding the muskalonge. COPEIA. *No. 146: 69–70.*

1925. A review of the fishes of the genus *Signalosa. Field Mus. Nat. Hist., Zool. Ser., 12 (11): 137–46.*

1927. Pike, pickerel and muskalonge. *Field Mus. Nat. Hist., Zool. Leaflet No. 9: 153–204, pls. 1–8.*

1933. Notes on fishes of the family Hemirhamphidae. *Field Mus. Nat. Hist., Zool. Ser., 20: 41–66.*

1934. Just a suggestion (on keeping marine fishes as pets). *Home Aquar. Bull., April, 1934: 7–8.*

1934. Notes on the trouts of Labrador. COPEIA *(3): 127–33.*

1936. Reducing injurious effects of formaldehyde in the museum. *Museum News, 14 (2): 7–8.*

1937. Notes on sea-basses of the genus *Centropristes. Field Mus. Nat. Hist., Zool. Ser., 20 (23): 291–320.*

1938. Administrative species. *Science, n. s., 87: 550–1.*

1930–43. Numerous signed articles in the Field Museum News.

Retirement of E. W. Gudger

IN the summer of 1953, DR. EUGENE W. GUDGER, Honorary Associate in Fishes at the American Museum of Natural History, at the age of 87 and having trouble with his eyes, was warned by his physicians that he must no longer live and work in New York City, and reluctantly removed to Waynesville, North Carolina, his boyhood home where some of his kinfolk still reside. With his going, the Museum's fish department has lost one of its outstanding personalities and most widely known members.

DR. GUDGER officially joined the Museum's staff in May, 1919, to assist DR. BASHFORD DEAN in bringing out the third volume of a *Bibliography of Fishes* (published in 1923). For this task he was eminently qualified by his attention to details, tireless energy, and lifelong interest in the literature. After DR. DEAN's death he ably edited eight parts which form a monumental *Dean Memorial Volume* on *Archaic Fishes*, the last of which was published in 1942, meanwhile supervising the distribution of these and volumes of the Bibliography at home and abroad. Retired from other Museum responsibilities in 1938, his main interest lately was sorting and binding recent ichthyological papers, to make them convenient for reference in the fish department's *Dean Memorial Library.*

These activities led naturally to his very wide correspondence with ichthyologists all over the

world. He had a strong personal interest in those who had made and were making the literature of fishes, linked to that in the literature itself, and a host of professional friends, many of whom he probably had never seen; and they usually reciprocated his desire to be helpful to them.

The American Museum is a busy place. We have not time enough for things we should and plan, or wish and strive to do. Our colleagues drop in from the four corners of the earth, and it is difficult to give them the attention they give us under similar circumstances. DR. GUDGER always managed to give any visitor the time he considered him entitled to. He enjoyed helping others prepare their papers for publication. People were continually coming to his office with questions, or to share bits of information with him. When they had something he thought of interest he would urge them to publish it, and spare no pains himself helping them to do so in the way he thought it should be done. He dwelt in no ivory tower of learning; many of his natural history interests were shared by the man-in-the-street. These things contributed to his being valuable to the Museum as a contact with the outside.

He was an unusually purposeful person, not easily diverted from any course he was following. One may understand him and his career the better from a few things he has told us of his undergraduate college days. An early contact with a scholarly scientist made him wish to become a scientist and a scholar, and presently winning a science prize by hard work cemented that purpose. Being complimented on a well written exercise with the suggestion that he might have the ability to write for publication, may lie at the bottom of the long list of published titles to his credit. He recalls seeing a picture of a whale shark on the shore of a bay in Ceylon, in Holder's "Zoology," and some twenty years later was compiling everything that had been written about this largest of living fishes. Having been an eager pupil, he drifted into teaching as the available opportunity for employment, and became essentially a teacher always, sometimes advantageous, perhaps sometimes a handicap to his later career. Be that as it may, many indeed were those who had studied under him, and who were sufficiently appreciative to come to his New York museum office in later years, when keeping track of what they were doing and occasionally travelling to their reunions was his greatest pleasure.

DR. GUDGER's active field work in fishes, begun about 1905 under the auspices of Johns Hopkins University (of which he is an alumnus) at the U. S. Bureau of Fisheries laboratory, Beaufort, North Carolina, was continued there and later at the Tortugas laboratory of the Carnegie Institution, covering a period of ten years or so. But he approached ichthyology from the academic angle, and it was its literature where he latterly was most at home, and with a constant purpose to make it more available to others.—JOHN T. NICHOLS.

Bashford Dean Memorial Library

ALL ichthyological reprints intended for the Bashford Dean Memorial Library, in the American Museum of Natural History, should be addressed to: Dean Memorial Library, Department of Fishes, The American Museum of Natural History, New York, 24, New York. These reprints are now, as in the past when this work was in charge of DR. GUDGER, being catalogued and bound for the Dean Memorial Library for the use of ichthyologists and students.—C. M. BREDER, JR.

University of Florida

GRADUATE STUDIES at the doctoral level in the Department of Biology of the University of Florida include:

DAVID K. CALDWELL has begun a comprehensive study of the pinfish, *Lagodon rhomboides*. This work is being carried out under the direction of DR. ARCHIE F. CARR.

WILLIAM M. MCLANE is completing his study of the fishes of the St. Johns River. His work is under the supervision of DR. COLEMAN J. GOIN.

JOHN W. CRENSHAW, JR. is studying the distribution and relationship of the subspecies of *Pseudemys floridana* in the southeastern United States. DR. CARR is chairman of his committee.

RICHARD M. JOHNSON, on leave-of-absence from his teaching position at Tennessee Wesleyan, is beginning his studies with DR. CARR. His topic is a study of the ecological distribution of the reptiles and amphibians of East Tennessee as correlated with complexes of climate, soil, vegetation, physiography, and historical origin of the various elements of the herpetofauna.

PAUL G. PEARSON has, as the title of his problem, "A field study of *Scaphiopus holbrooki* populations." In this research, nearing completion after two years of field work on three populations of adult toads, emphasis was placed on the analysis of activity, growth, and mortality rates as affected by environmental factors. A detailed study of the home range, dispersal, and general behavior of the toads relative to their burrows was conducted. One phase of the study dealt with a semi-controlled field experiment testing density effects on the above-mentioned factors. The work is under the direction of DR. W. C. ALLEE.

EDWIN H. MCCONKEY is beginning his doctoral work with DR. CARR and has chosen for his study: "The Pleistocene and Recent zoogeography of the genus *Terrapena* in southeastern United States."

WALTER AUFFENBERG plans to study the fossil

lizards and snakes of Florida. This work is under the supervision of DR. ARNOLD B. GROBMAN.

KEITH L. HANSEN is studying the life history of *Rana heckscheri* including a week-by-week investigation of the frog's growth, movements, and home range. An allometric growth study of the tadpole and plans for investigation of schooling habits are also included. DR. GOIN is chairman of his committee.

RICHARD HIGHTON has recently completed his master's thesis entitled, "The life history of the slimy salamander, *Plethodon glutinosus*, in Florida," and is continuing a study on the geographic variation of this species.

Chicago Natural History Museum

MR. CLIFFORD H. POPE, Curator of Amphibians and Reptiles for 13 years, resigned December 31, 1953, after a six-month leave of absence. He has been preparing a popular account of the reptiles and intends to devote full time to this and other writing. He will continue his connection with the Museum as Research Associate in the Division of Amphibians and Reptiles.

MR. ROBERT F. INGER, Assistant Curator of Fishes, has been appointed Curator of Amphibians and Reptiles, effective January 1, 1954.

PEARL SINOTA, secretary in the Division of Mammals, has been appointed an assistant in the Division of Fishes.

Revolving Research Fund

OUR Revolving Research Fund, that failed to revolve, was established at the Pittsburgh meeting, held on April 16, 1946, by the Board of Governors. The fund was designed to furnish small grants, not otherwise readily procurable, for the furtherance of specific research projects, in any appropriate phase of ichthyology and herpetology, to young members of our Society.

One sentence in the circular letter of June 10, 1946, that appealed to the members for contributions to the fund, read as follows: "Grants will be made only to individuals doing research. No strings will be attached though the recipients will be invited to replenish the fund, when able to do so, by an amount at least as large as that which they received. It is hoped that these and other contributions will maintain the fund indefinitely."

$1,553.25 was contributed by members and friends within eighteen months after the appeal was made; a gift of $50.00 was received in 1951, and unexpended prize monies of $105.00 added to the fund brought the total receipts to $1,708.25 by the end of 1951.

From February, 1948 to date the sum of $1,438.00 has been expended for nine grants. Only one grantee has repaid the amount received by him, namely $150.00 The present balance of $420.25 is insufficient to keep the fund alive.

An urgent appeal is made to all members, particularly to those who benefited from the fund, to make contributions NOW so that this highly meritorious fund may be kept "revolving." Kindly make your check to "Amer. Soc. Ichthy. and Herpet." and send it to FREDERICK H. STOVE, Chairman, Revolving Research Fund Committee, 604 Rosemont Street, La Jolla, California. Contributions are deductible on income tax returns.

Collectors in México

BECAUSE of the tremendous increase in the number of faunal studies in México on the part of biologists from other countries, particularly the United States, information on the proper method of obtaining scientific collecting permits and regulations concerning the obligations on the part of the collectors is set forth briefly in the following paragraphs in the hope that it will prove helpful.

Scientific collecting permits are required of all investigators who contemplate taking specimens of amphibians, reptiles, birds and mammals in México. These permits are issued free of charge by the Dirección General Forestal y de Caza, Secretaría de Agricultura y Ganadería, Calle Mariscal No. 11, México, D. F. All correspondence concerning scientific collecting permits should be addressed to that office. Any representative, including students, of a scientific or cultural institution who demonstrates qualifications satisfactory to the Mexican Government is eligible to receive a permit.

Applications should be made at least one month in advance, stating the type of study to be undertaken, the part of México in which the study is to be made, and the duration of the field phase of the investigation. A recent photograph of the applicant should accompany the application.

Recipients of scientific collecting permits issued by the Mexican Government are under obligation to fulfill the following requirements as stated in detail on each permit.

a. To return one specimen of each species collected to the Mexican Government. (These specimens will be deposited in the collections of the Instituto de Biología of the University of México, or in some other reliable scientific institution).

b. To submit a summary of field observations and a list of specimens collected.

c. To send reprints of publications and reports based on the material gathered in México.

d. To cooperate in game law enforcement by reporting cases of game law violations.

e. To abide by the game laws of México, paying particular attention to the seasonal hunting regula-

tions, and to cooperate fully in regard to those species completely protected from hunting. Permission to take species on the protected list may in certain cases be issued at the discretion of the Dirección General Forestal y de Caza.

Authorization for temporary importation of firearms and ammunition and for carrying firearms in pursuit of scientific studies in México must be obtained in advance from the Departamento de la Industria Militar. This application may be made to any of the branch offices located in the various custom houses along the Mexican–U. S. border, or directly to the central office at Tecamachalco, D. F.—BERNARDO VILLA R., *Departamento de Caza, Dirección General Forestal y de Caza, México, D. F. México.*

News Notes

HARRY C. FASSETT died on December 9, 1953, at the age of eighty-three. He joined the ALBATROSS when the ship reached San Francisco in 1889 and stayed on until the close of the Philippine Expedition in 1910. As Captain's Clerk he was responsible for keeping the records of stations and I have not heard of any errors being found in these. He was a very meticulous worker. I think he was the last survivor of the group which made the ship famous. He told me once about the difficulties encountered in the work about the Channel Islands. They lost some trawls and resorted to dredging to a considerable extent, if I remember correctly. That may account for the fact that some fishes were missed which one would expect would have been taken. Records of shells taken are very extensive.—G. DALLAS HANNA, *California Academy of Sciences, San Francisco.*

DR. GILES W. MEAD, who recently completed his doctorate at Stanford University, is now employed by the U. S. Fish and Wildlife Service at Woods Hole where he is identifying larval fishes collected by the ALASKA in the Gulf of Mexico.

MR. HARVEY BULLIS of the U. S. Fish and Wildlife Service, who was stationed temporarily in Washington, D. C., has returned to Pascagoula, Mississippi, to resume work on the OREGON surveys.

The Report of the Colloquium embodying the nomenclatorial decisions of the XIVth International Congress of Zoology at Copenhagen, 1953, is available at the low price of seventy-five cents, postpaid, from the International Trust for Zoological Nomenclature, Publications Office, 41 Queen's Gate, London S. W. 7, England. This important document will serve to guide zoologists until the formal publication of the revised International Rules of Zoological Nomenclature.

The attention of herpetologists is called to two articles by FREDERICK B. TURNER (1952, Yellowstone Nature Notes, 5: 57; 59). The first reports aggregations of newly transformed toads (*Bufo b. boreas*) concentrated in heaps or piles; the other describes an encounter between a gartersnake (*Thamnophis e. vagrans*) and a tiger salamander (*Ambystoma t. melanostictum*).

H. R. ASHLEY, 67 Elliott Avenue, Yonkers 5, New York, would appreciate information concerning locations of populations of *Clemmys muhlenbergi* in northern New Jersey and southern New York. MR. ASHLEY plans to make a series of both still and motion pictures "on the spot."

L. NEIL BELL, Department of Zoology, University of Miami, Coral Gables, Florida, WILLIAM E. DUELLMAN, Museum of Zoology, University of Michigan, Ann Arbor, and ALBERT SCHWARTZ, Charleston Museum, Charleston, South Carolina, are engaged in a survey of the herpetofauna of southern peninsular Florida and the Florida Keys. They would appreciate records of amphibians and reptiles from Broward, Collier, Dade, and Monroe counties, as well as observations on the life histories and habits of the species in that area.

Authors' correction: 1953, COPEIA (3): 60, first column, line 5. Replace *Crotalus horridus horridus* (Linnaeus) by *Crotalus horridus atricaudatus* Latreille.

GEORGE P. MEADE, one of the most respected members and past Vice-President of the ASIH, host par excellence (New Orleans meetings!), devoted student of snakes, and leader in civic enterprises, was designated Man of the Year (1953) at the recent annual meeting of the Carbohydrate Division of the American Chemical Society. The fall issue of the "Sugar Molecule" (1953, Vol. 7, No. 3) devoted six thrilling pages to the distinguished accomplishments of this unusual man under the well chosen title "Honors to a veteran."

DR. AFRANIO DO AMARAL has been reinstated as Director of the Instituto Butantan, São Paulo, Brazil, by judicial decree. He will resume his duties at the institute on his return from attendance at the meetings of the 14th International Congress of Zoology at Copenhagen. He took part in the Colloquium on Zoological Nomenclature and in the meetings of the International Commission for Zoological Nomenclature.

Doctoral candidates doing their thesis work in herpetology at the Museum of Vertebrate Zoology, University of California (Berkeley), are as follows: ROBERT GLASER, Growth and head form in lizards of the genus *Xantusia*; JOSEPH B. GORMAN, Biosystematics of salamanders of the genus *Hydromantes*; ERNEST L. KARLSTROM, Systematics and ecology of the Yosemite toad, *Bufo canorus*; WILLIAM J. RIEMER, Systematics and ecology of western

species of *Triturus*; GERSON M. ROSENTHAL, Microclimatic factors in relation to local distribution and tolerance of *Aneides*; and RICHARD G. ZWEIFEL, An ecological and systematic study of *Rana boylei* and its relatives.

The Committee on Common Names of Amphibians and Reptiles has been expanded and reactivated, with MR. ROGER CONANT serving as Chairman. Other members of the Committee are FRED R. CAGLE, COLEMAN J. GOIN, CHARLES H. LOWE, WILFRED T. NEILL, N. GRAHAM NETTING, KARL P. SCHMIDT, CHARLES E. SHAW, and ROBERT C. STEBBINS. Using the recent edition of the *Check List of North American Amphibians and Reptiles* as a basis for discussion, the Committee plans to draw up a list of names to be recommended by the Society. Members of the Society are invited to send in suggestions concerning common names, when strong reasons can be advanced for proposing names other than those employed in the Check List. All suggestions must be submitted to MR. CONANT prior to July 1 in order to allow sufficient time to collate such suggestions and have them ready for the Committee to act upon at the Annual Meeting in Gainesville, Florida early in September. Correspondence should be addressed to MR. ROGER CONANT, Philadelphia Zoological Society, 34th Street and Girard Avenue, Philadelphia 4, Pennsylvania.

Recently (1953, British Jour. Herpetology, 1 (9): 173), DR. F. R. IRVINE, 32 Tavistock Square, London, W. C. 1., England, wrote that on the Gold Coast of Africa there has long been the belief that snakes have a fondness for the fleshy fruit of *Momordica foetida* and of other plants. He also said that, years after having heard of the belief, he found seeds that were apparently those of *Momordica* in a snake's stomach. DR. IRVINE has recently written the Herpetological Editor that he now has confirmation that the serpent involved is *Dasypeltis*, the egg-eating snake. DR. IRVINE would like to hear from any COPEIA reader who might have additional information on fruit-eating by snakes.

Word is received from ERNA MOHR that GEORG DUNCKER, Honorary Foreign Member of the Society, died on July 27, 1953, at the age of 83.

PRESIDENT BOGERT has appointed DR. MYRON GORDON as the representative of ASIH on the council of AAAS. His appointment begins immediately and terminates at the end of 1956. The ASIH, at the meetings in New York, voted to affiliate with the AAAS; the affiliation is now an accomplished fact.

The University of Washington School of Fisheries offers financial assistance to outstanding graduate students, undergraduate students and high school seniors in the form of scholarships with awards of from $250 to $500 per school year, and by assistantships and part-time employment with stipends ranging from $600 to $2,000 per year. The assistantship or part-time employment usually is, but need not necessarily be, on research leading to an advanced degree. Both summer and part-time employment are usually available in a number of fisheries research organizations located on or near the university campus. For further information, address DR. RICHARD VAN CLEVE, Director, School of Fisheries, University of Washington, Seattle 5, Washington.

The operating budget of the Virginia Fisheries Laboratory was increased substantially by the General Assembly of Virginia at its 1954 session. Construction will begin on a new research vessel this summer, and several biologists will be added to the research staff. The increase was in part the result of recommendations made by a Legislative Study Commission, appointed by GOVERNOR BATTLE in 1953 to study the recent serious declines in fish landings in Chesapeake Bay. Hardest hit have been the fisheries for croaker (*Micropogon undulatus*) and gray sea trout or weakfish (*Cynoscion regalis*). Particular emphasis will be directed toward these species in the expanded research program.

DR. WALTER C. BROWN, of Menlo College, California, who is associated with the Natural History Museum of Stanford University in work on Pacific Islands herpetology, has received a Fullbright Fellowship to the Philippines for the year 1954-55. DR. BROWN will be located at Silliman University, Dumaguete, Negros Island, where he will both teach and carry on herpetological research.

DR. JOHN C. BRIGGS, Research Associate in the Natural History Museum of Stanford University, who is preparing a world monograph of the fishes of the order Xenopteri, has just returned from a round-the-world trip to study clingfish material preserved in various museums and laboratories. Among the ichthyological centers visited were those of Sydney, Calcutta, Paris and London.

At the request of the Peruvian Government through the cooperation of the Institute of Inter-American Affairs, USA, DR. ROBERT R. MILLER will spend from June 15 to August 15 on laboratory and field work in Peru, assisting in the development of freshwater ichthyology.

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